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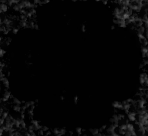

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EFFICIENCY OF PROPULSIVE MACHINERY AND LATE DEVELOPMENTS IN NAVAL ENGINEERING

BY LIEUTENANT-COMMANDER H. C. DINGER[1], U. S. N., WASHINGTON, D. C.

Non-Member

IN January, 1912, Capt. C. W. Dyson presented a paper before the Engineers' Club of Philadelphia, entitled Propulsive Machinery and Oil Fuel in the U. S. Navy, which was followed later in the same year with a paper entitled Engineering Progress in the U. S. Navy, read by the then Engineer-in-Chief, Rear-Admiral H. I. Cone, before the American Society of Naval Architects and Marine Engineers at their annual meeting in New York City.

The first of these papers contained a comparison of the performances of the reciprocating-engined vessel *Delaware* and the Curtis turbine-engined vessel *North Dakota,* while the second paper contained a comparison of the performance of the *Delaware* and the Parsons turbine-engined vessel *Utah.* In both of these comparisons the decided superiority in economy of the reciprocating engine over the turbine for battleship propulsion was fully demonstrated.

That this apparent superiority was due to faulty practice in the design of propellers in the case of the Parsons turbine, and to both turbines and propellers in the case of the Curtis turbine, has been demonstrated by the trials of later vessels, in which the turbine revolutions have been very considerably reduced; and in the cases of Curtis turbines the turbine design has been radically changed in quite a number of particulars. In the cases of the latest two turbine-engined vessels, the economy has been still further improved by fitting cruising turbines driving the main shafting through mechanical reduction gear.

Since the trials of the *Delaware, North Dakota, Utah* and her sister ship *Florida,* the following vessels have been completed and tried and commissioned: *Arkansas, Wyoming, New York, Texas, Oklahoma, Nevada* and *Pennsylvania.* Of these vessels the *Arkansas* and *Wyoming* are sister ships and are fitted with Parsons turbines on four shafts. The *New York* and *Texas* are alike and have reciprocating engines on two shafts. The *Oklahoma* and *Nevada* are also sister ships, the first having reciprocating engines while the other has Curtis turbines with cruising turbines and reduction gear. Both vessels have two shafts. The latest vessel, the *Pennsylvania,* is also fitted with Curtis turbines and with cruising turbines and reduction gear, but the power is divided among four shafts.

In tracing the advance in economy in turbine propulsion, that vessel of each pair of sister ships showing the better trial performance will be considered in order to eliminate favoritism of one type over the other, and with this object in view the following vessels will be used in the argument:

1 Reciprocating-engined vessels *Delaware, New York, Oklahoma.*
2 Parsons-turbine-engined vessels *Utah, Arkansas.*
3 Curtis-turbine-engined vessels *North Dakota, Nevada, Pennsylvania.*

In order to furnish a proper understanding of the conditions of operation of the machinery, the characteristics of the vessels' hulls, their machinery and their propellers, must be at hand for reference; and these characteristics are given in Tables 1-3.

The following is a detailed description of the turbines of the *Nevada* and *Pennsylvania:*

[1] Bureau of Steam Engineering, Washington, D. C.

Presented at a meeting of the Philadelphia Section of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS, May 23, 1916.

SYNOPSIS

In papers read early in 1912 by Rear-Admiral H. I. Cone and Capt. C. W. Dyson, U. S. N., comparisons were made of the performances of turbine-engined and reciprocating-engined naval vessels that demonstrated the superiority of the latter for battleship propulsion. That this superiority was only apparent, however, and was due to faulty design of turbines and propellers, has been shown by the trials of vessels since constructed.

In tracing the advance in economy in turbine propulsion the author selects as good examples of modern practice the reciprocating-engined vessels *Delaware, New York* and *Oklahoma;* the Parsons-turbine-engined vessels *Utah* and *Arkansas;* and the Curtis-turbine-engined vessels *North Dakota, Nevada* and *Pennsylvania.* He gives tabulated details regarding the hulls and machinery of these vessels and also curves plotted from their trial-trip data.

In one set of curves shaft or indicated horsepowers are plotted against effective horsepowers, giving curves of relative propeller efficiency which indicate graphically the improvement in propeller design made in succeeding vessels, and which show the reciprocating-engined vessels to be decidedly superior above 12,000 effective h.p. In another set B.t.u. per effective horsepower are plotted against effective horsepowers, giving a comparison of combined engine and propeller efficiencies. In a third set revolutions per minute are plotted against effective horsepowers.

So far as economy at the different speeds is concerned, the curves show that there is but slight choice between the different types of machinery when they have proper propeller efficiency. At very low powers the reciprocating engine is about as economical as the geared cruising turbine, and both of these are more economical than directly connected cruising turbines; and it is evident that matters other than economical performance should decide the question of type of prime mover. When losses are guarded against it is the range of temperature that really counts in securing efficient propulsive machinery; hence the most effective measures are obviously the use of superheat and the highest practicable vacuum, the best possible utilization of feed-heating apparatus, and the economical operation of auxiliaries. These latter can become very wasteful, but in the best cases the percentage of available heat used by them has been reduced to about 5 per cent of the total at full power.

The geared turbine and the electric drive are recent innovations which show decided economy and a material saving in weight over directly connected units. For large capital vessels the electric drive is to be preferred on account of (1) greater flexibility in shaft and piping arrangements, (2) better economy at cruising ranges, (3) better arrangement of generator rooms, boilers, etc., (4) better handling conditions and greatly improved power for backing, and (5) the practicability of using high superheat; also (6) parts of machinery can undergo repair while other parts are in operation at a very large percentage of the total power of the vessel. Gearing is more suitable for light, high-powered vessels of the destroyer or scout type.

The paper discusses briefly recent improvements in auxiliary machinery, making special mention of the adoption of the small steam turbine for driving forced-draft blowers, and of the use of gearing for turbine-driven generators, pumps and blowers. Attention is also called to the fact that the problem of the naval engineer is largely one of saving weight and space, and that as the principal method of accomplishing this is to install high-efficiency machinery, the desirability of coöperation of naval engineers with the industrial engineers of the country is obvious.

U. S. S. Nevada Turbine Data.—The high-pressure turbine has five wheels and two drums, the 5th-stage wheel being secured to the forward drum, the steam being divided after leaving the wheel stages. The wheels are separated from each other by diaphragms containing the steam nozzles. There is one stage on each wheel with two rows of buckets each, except the 1st-stage wheel which has four rows, all having a pitch diameter of 132 in. The forward drum, 6th to 14th stages, inclusive, has nine rows of buckets with a pitch diameter of 119 in., and the after drum, 15th to 30th stages inclusive, has 16 rows of buckets with a pitch diameter of 118⅝ in.

The low-pressure turbine has one drum of 38 stages and 38 rows of buckets for ahead conditions, and one wheel and one drum for backing. The backing wheel, one stage, has four rows of buckets with a pitch diameter of 137.55 in., and the drum, nine stages, has 11 rows of buckets with a pitch diameter of 120 in. The backing wheel and drum are separated by a diaphragm containing steam nozzles.

Pennsylvania Turbine Data.—The high-pressure ahead turbine has three wheels and two drums, the 3d-stage wheel being secured to the forward drum. The wheels are separated from each other by diaphragms containing the steam nozzles. There is one stage on each wheel, with three rows of buckets (132 in. P. D.), except the 1st-stage wheel which has four rows of buckets. The forward drum has 18 rows of buckets and the after drum 21 rows of buckets (both 120 in. P. D.).

The low-pressure ahead and astern turbine has two drums. The forward drum has 42 rows of buckets for ahead conditions (138 in. P. D.), and the after drum 13 rows of buckets for astern conditions (120 in. P. D.). The high-pressure astern turbine has three wheels and one drum; each wheel has three rows of buckets except the first stage, which has five rows, (108 in. P. D.). The drum has 17 rows of buckets (84 in. P. D.).

The high-pressure cruising turbine has four wheels, two rows of buckets on each, except the first has three (30 in. P. D.). The low-pressure cruising turbine has six wheels, two rows of buckets on each (30 in. P. D.).

The cruising turbines for the *Nevada* were designed to give requisite power to pass steam through them up to a speed of 15 knots. Those for the *Pennsylvania* were designed to pass steam through them up to a speed of 12 knots. They were, however, used up to 15 knots by making use of special by-passes. In both vessels the cruising turbines may be used at higher speeds than those originally designed by keeping the cruising turbines in operation and at the same time admitting some live steam into the main high-pressure turbines.

TABLE 1 HULL CHARACTERISTICS OF VESSELS

	Delaware	*North Dakota*	*Utah*	*Arkansas*	*New York*	*Oklahoma*	*Nevada*	*Pennsylvania*
Length on load water line	510 ft. 0 in.	510 ft. 2¼ in.	510 ft. 0 in.	554 ft. 0 in.	565 ft. 0 in.	575 ft. 0 in.	575 ft. 0 in.	600 ft. 0 in.
Beam	85 ft. 2⅝ in.	85 ft. 2½ in.	88 ft. 2½ in.	93 ft. 2⅝ in.	95 ft. 2⅝ in.	95 ft. 2⅝ in.	95 ft. 2⅝ in.	97 ft. ½ in.
Draught on trial	27 ft. 2 in.	26 ft. 11⅜ in.	27 ft. 10⅞ in.	27 ft. 11⅞ in.	27 ft. 9½ in.	28 ft. 6 in.	28 ft. 3⅞ in.	28 ft. 9¾ in.
Displacement on trial, tons	20,209	20,051	21,268	25,496	26,300	27,500	27,222	31,400
Coefficient of fineness, block	0.6000	0.6000	0.5837	0.6220	0.6100	0.6170	0.6080	0.6460
Coefficient of fineness, mid-section	0.9798	0.9810	0.9792	0.9850	0.9900	0.9840	0.9820	0.9820

TABLE 2 MACHINERY CHARACTERISTICS OF RECIPROCATING-ENGINED VESSELS

	Delaware		*New York*		*Oklahoma*	
Engines, type	Vertical, inverted, 4-cylinder, triple-expansion					
Engines, number	2		2		2	
Cyl. diam., in., high pres.	38.5		39		34.98	
Cyl. diam., in., medium pres.	57		63		59	
Cyl. diam., in., low pres.	(2) 76		(2) 83		(2) 78	
Stroke, in.	48		48		48	
Clearances (total per cent)	Top	Bottom	Top	Bottom	Top	Bottom
High-pres. cyl. (H.P.)	15.57	16.77	14.29	13.54	7.226	9.586
Med.-pres. cyl. (M.P.)	12.71	14.43	12.18	14.85	9.284	12.499
Low-pres. cyl. (L.P.)	11.91	13.04	13.75	16.30	8.900	12.400
Ratio H.P.:M.P.	2.22		2.61		2.890	
Ratio M.P.:L.P.	3.58		3.47		3.508	
Ratio H.P.:L.P.	7.92		9.06		10.130	
Valves, type	Piston, with short, straight ports.					
Valves, number	1 H.P., 2 M.P., 4 L.P.		1 H.P., 2 M.P., 4 L.P.		1 H.P., 2 M.P., 4 L.P.	

TABLE 3 MACHINERY CHARACTERISTICS OF TURBINE-ENGINED VESSELS

	Arkansas, Utah and Florida	*North Dakota*	*Nevada*	*Pennsylvania*
Type of turbines	Parsons reaction	Curtis, wheel stages only	Curtis, wheels and drums	Curtis, wheels and drums
Number of shafts	4	2	2	4
Rotor diameters, in.*				
High-pressure	71	144	132-138⅝	132-120
Low-pressure	97	..	120	138
High-pressure cruising	71	..	38-41	30
Intermed.-pres. cruising	70	..	....	.....
Low-pres. cruising	..	..	....	30
High-pressure astern	71	..	137.55	84-108
No. of Stages, high-pres.	6 (91 rows)	9	5 wheel 25 drum	4 wheel stages 39 rows on drums
No. of Stages, low-pres.	6 (39 rows)	..	38	55 " " "
Revolutions per minute	320	280	212	210
Steam pres., lb. per sq. in.	200	250	250	250

* All pitch diameters except in second column.

COMPARISON OF ECONOMICAL PERFORMANCES

The curves in Figs. 1 and 2 have been plotted in order to establish a definite basis of comparison of the economical performances of the different vessels, and it is believed that the comparison thus made is very easily comprehended. The curves are plotted from the trial-trip data of the various vessels, which are believed to be reliable, but which cannot be taken with the refinement of a laboratory experiment.

CONSTRUCTION OF CURVES

Fig. 1, lower part, gives the effective horsepower and revolution curves for each of the several vessels. Fig. 1, upper part, gives the effective horsepower and indicated or shaft horse-

power curves for each of the several vessels. As plotted they are really curves of relative propeller efficiency, and the closer the curve comes to the horizontal the greater the propeller efficiency. The curves indicate graphically the general improvement in propeller design made in succeeding vessels. It will be seen that curves of the two latest vessels, the *Oklahoma* and *Pennsylvania,* run fairly close together up to an effective horsepower of 12,000, though one is a turbined vessel running at 181 r. p. m., and the other a reciprocating-engined vessel running at 118 r. p. m.; but above this point the reciprocating engine propellers are decidedly superior.

Fig. 2 gives the effective horsepower and B.t.u. utilized, obtained by plotting the value of $W H \div$ (E. H.P.), where

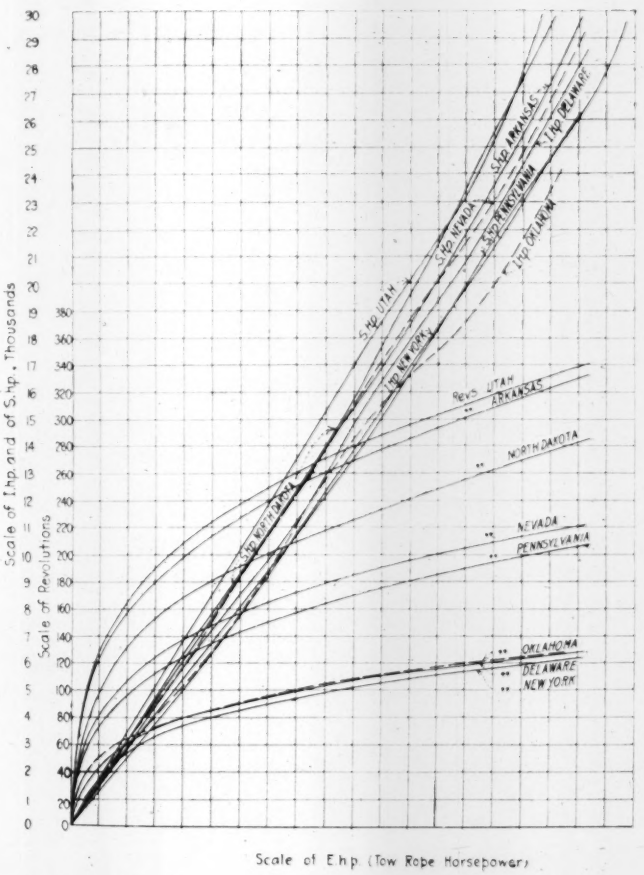

FIG. 1 COMPARATIVE PERFORMANCES OF NAVAL VESSELS

W = total water consumption per hour at point where the effective horsepower (E. H. P.) mentioned is used, and H = total heat of one pound of steam at boiler less feed temperature. These curves, therefore, give a comparison of combined engine and propeller efficiency, eliminating the boilers. Similar curves might be plotted showing the engine efficiency only. But as the type of machinery affects the propeller efficiency, it is a better comparison to have the combined efficiency of engines and propellers.

In plotting these curves, where saturated steam is used the steam is assumed to be dry. Where superheated steam is used the temperature of steam recorded is employed. It is believed that the curves are truly comparable graphs of the economical efficiency of the machinery of the different vessels, and are unique in this particular, since they take into account propulsive work performed per heat unit supplied in the steam to the engine. They also take into account water for all purposes, except for the *North Dakota* the water for dynamos is excluded.

Any other vessels for which the water consumption, steam pressure, feed temperature, shaft horsepower and effective horsepower are known, can be compared in the same way and the relative efficiency of the machinery shown.

The disclosures from the curves of the B.t.u. per effective horsepower are extremely interesting. The *New York* here shows the best performance, and this represents the combination of efficient propellers, good reciprocating engines, and the use of a moderate degree of superheat. In comparing the *Delaware, New York* and *Oklahoma,* we find their propeller efficiencies stand in the following order: 1 *Oklahoma;* 2 *New York;* 3 *Delaware.* The order of their economical efficiencies is: 1 *New York;* 2 *Delaware;* 3 *Oklahoma.* Both the *New York* and *Delaware* have superheat; the *Oklahoma* has none. The relative standing of the *New York* and *Delaware* is largely accounted for by the difference in propeller efficiency. The *Oklahoma* has better propeller efficiency and fully as good, if not better, engines, hence one is easily led to the conclusion that the falling off in the economical efficiency of the *Oklahoma* is due to the non-use of superheat. Similarly the performance of the *Nevada* and of the *Pennsylvania* could have been improved nearly 10 per cent by using superheat.

The *Nevada* and the *Pennsylvania* are fitted with geared cruising turbines. The superior economy secured by these over other turbine vessels is clearly shown by the curves. The curves also indicate that the Parsons vessels at high speeds give about the same economical result as the Curtis-turbined *Nevada* and *Pennsylvania.* The propeller efficiencies of the

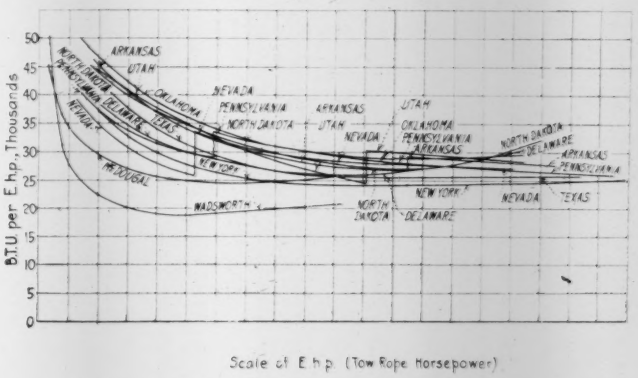

FIG. 2 COMPARATIVE PERFORMANCES OF NAVAL VESSELS

Nevada and *Arkansas* are about the same. However, within the range of the intermediate-pressure cruising turbine the Parsons vessels are superior, while at very low speeds the economy in the turbine vessels is about the same. The *Pennsylvania* at high power shows slightly better economy than the *Nevada,* this being expected since it is a later and somewhat better design, and better propeller conditions due to the use of four screws running at same revolutions are obtained. At low power the *Nevada* gives better economy results. The curves of the *Utah, Arkansas, Nevada* and *Pennsylvania* are really a series of curves, as they jump from one combination of turbines to another.

In plotting the curves, that for each condition is laid down and carried up to the point where the next combination of turbines comes in. Actually, by means of by-passing steam, the results will not follow the separate lines; but, as the limit

of one combination is reached, by-passing is resorted to and a better result secured than if a complete shift to the next combination were made.

As far as economy at the different speeds is concerned, there is not much choice between the different types of machinery when they have proper propeller efficiency. At very low powers the reciprocating engine is about as economical as the geared cruising turbine, both of these being more economical than directly connected cruising turbines. The use of superheat would improve the performance, however, especially that of the reciprocating engine and impulse turbine.

The foregoing indicates that when all advantages of design are used, about the same economical results are secured with either reciprocating engines, Parsons turbines or Curtis turbines, and that other matters besides mere economical performance should decide the choice of prime mover as between the several types. It also goes to show that when the losses are properly guarded against it is the range of temperature that really counts in securing efficient propulsive machinery. Therefore, the most effective measures that can be applied are those which increase the range of temperature that can be used and those which conserve the use of the heat units supplied. Hence we have reasons for use of superheat, the employment of the highest possible vacuum practicable, the best possible use of feed-heating apparatus, and economical operation of auxiliaries.

The curves of the destroyers *McDougal* and *Wadsworth* have also been plotted, Fig. 2. Owing to large differences in hulls and speeds, the destroyers are not directly comparable with the battleships, but they are comparable with each other, and the curves indicate the general efficiency of the propulsive machinery of representative destroyers, and strikingly show the economical advantage secured by use of gearing.

STEAM USED BY AUXILIARIES

A number of tests have recently been made to determine the percentage of total steam used by the auxiliaries of naval vessels, and following are given the approximate values obtained from averaging these results:

Capital vessels	Speed, knots	10	15	19	21	..
	Per cent of total steam	38	30	18	14	..
Destroyers	Speed, knots	12	16	20	25	30
	Per cent of total steam	27	21	17	13.5	12

It will be noticed that the percentage of steam used by the auxiliaries in the case of the destroyers is considerably less than that used by the large vessels. This condition accounts for the fact that the destroyer machinery proves to be more efficient than that of the capital vessels. The above are average results for certain average conditions, but it is believed that the steam consumption of the auxiliaries can, by special care and attention, be reduced from 10 to 25 per cent below the average conditions which obtained when the water consumption was measured.

The auxiliary exhaust that is not used in the feed heaters is used in the low-pressure turbines, so that under the conditions of actual operation the auxiliaries do not use the full extent of this percentage, and all over about 10 per cent is used in the low-pressure turbine, where it will give approximately half the return that the same amount of live steam entering at the throttle would give. Therefore, strictly speaking, the auxiliaries, except electric generators, should be charged with only about half of the above percentages, since they exhaust at about 10 lb. pressure, and this exhaust is used effectively both in the feed heater and in the turbines. The following table has been compiled to show the approximate steam consumption of various auxiliaries on large vessels for full-power conditions. The amounts of steam used are quite variable and depend not only upon the design of the auxiliaries but also on the method of operation. The following gives the percentages of steam used by the auxiliaries.

	Per cent of total steam
Feed pumps	3.0 to 5.0
Circulating pumps	1.5 to 2.5
Air pumps and condensate pumps	0.2 to 0.6
Forced draft blowers	1.5 to 3.0
Lubricating pumps	0.1 to 0.2
Oil-fuel pumps	0.2 to 0.4
Total for auxiliary machinery necessary to operate main engines	6.5 to 11.7
Bilge pumps, ice machines, steering engine and other miscellaneous machinery	1.0 to 4.0
Dynamo plant other than forced-draft blowers	1.0 to 2.0
Total	8.5 to 17.7
Evaporating plant, depending on rate of use.	

The principal steam users among the auxiliaries are the feed pumps, circulating pumps and forced-draft blowers; the other auxiliaries of naval vessels use a relatively very small percentage of steam.

The introduction of turbine-driven centrifugal feed pumps will reduce the steam consumption for feeding. The consumption of circulating pumps is reduced by the use of scoop injection for condensers on destroyers and scouts, and on other vessels where this is practicable. The consumption for forced-draft blowers is reduced by using larger blower units and by having arrangements made whereby two blower units are compounded. Compounding has actually been made use of in several instances.

Electric forced-draft blowers have been used on a considerable number of large vessels. While this practice is fairly economical, the desired speed regulation is not secured, and electrically driven blowers are not well-suited to oil-burning installations. The objections to the electrically driven blowers are:

(1) Difficulty in obtaining as variable a speed as is desirable and necessary with oil fuel. With steam-turbine drive minute regulation is possible.

(2) Additional generating units have to be started when a considerable number of blowers are started.

(3) Starting and stopping of blowers creates a very variable load, and in order to accommodate this load extra generators have to be kept in operation.

(4) Electrically driven blowers cannot be efficiently operated at low speeds, and in many cases a low speed is desirable to suit the boiler output at any one time.

(5) Circuit breakers are likely to blow, and if this happens flare backs may take place and all steam generation be stopped until the blowers are again started. With steam-turbine drive it is very unlikely that all blowers would stop at the same time.

It must be remembered that the auxiliary exhaust is now invariably used for feed heating and in some instances for distilling, so that the actual heat used by the auxiliaries is really from 4.5 to 9 per cent of the total instead of from 8.5 to 18 per cent.

The auxiliaries can, by lack of care in design, condition and operation, become very wasteful, so that they do, in cases, use two or three times the amounts stated. But in our best per-

formances we are reducing the percentage of available heat used by the auxiliaries to approximately 5 per cent of the total at full power. By improvement in design and operation this figure can be still further reduced, but no very marked further saving in steam used for auxiliaries is practicable.

NEW TYPES OF MACHINERY

In the search for economy and efficiency there are new types of naval machinery to deal with which are causing both the directly connected turbine and the reciprocating engine to be superseded. These are the geared turbine and the electric drive. The hydraulic transmitter has also been considered abroad. These innovations, which have actually been tried in quite a number of cases both on naval vessels and in the merchant marine, will secure an advantage in economy of 10 to 15 per cent as compared with the directly connected units, as well as a material saving in weight. In this connection note the position of the curves of the *Wadsworth*, our first U. S. geared destroyer. For certain types of vessels the geared turbine has the advantage over the electric drive. For other types the reverse is the case. For large capital vessels of high speed the electric drive appears to have the advantage for the following reasons:

(1) There is much more flexibility so far as arrangement and shaft and piping connections are concerned.

(2) Better economy at cruising ranges is secured.

(3) Generator rooms, boilers, piping, etc., can be more adaptably arranged. The necessity for bringing large steam pipes through boiler compartments and back to the engine room is avoided, electric conductors taking the place of these large pipes.

(4) Parts of machinery can be undergoing repair while other parts are in operation at a very large percentage of the total power of the vessel.

(5) Much better handling conditions are secured, and a greatly improved power for backing is present without the complication caused by the use of backing turbines.

(6) It is entirely practicable to use a high degree of superheat.

GEARING VS. ELECTRIC DRIVE

Gearing is more suitable than the electric drive for light, high-powered vessels of the destroyer or scout type, because it is more compact and, within the limitations of these vessels, is lighter than the electric drive. It is a little more economical at high power but not as economical at cruising and intermediate speeds. Gearing is more suitable for light, high-powered installations where weight and space are cut to the minimum and where the power is not so great but what the leads of steam piping and shafting can be satisfactorily handled. The turbine-reduction-gear layout does not permit of as much protection to the machinery, and the handling arrangements and flexibility are not as good. In the scout and destroyer designs, machinery of the following characteristics may be applied: Powers up to 25,000 shaft h.p. on one reduction gear set, two pinions being utilized. Water consumption of 10.5 to 11 lb. per shaft h.p. at full power; machinery weight, total, about 40 lb. per shaft h.p. Such machinery contemplates the use of scoop injection condensers, and also the possible use of steam ejectors or kinetic tanks in place of air pumps. Such machinery also requires the reduction of all the auxiliaries to the lowest limit that is practicable.

A comparison of gearing and electric drive on various points is given below. The advantage is not all one way, and the special conditions of vessel and her service requirements will govern the choice of one type or the other.

GEARING	ELECTRIC DRIVE
Weight	
The initial advantage rests with the gearing, since the gear will not weigh as much as the generator and motor combined. As very large powers are used and a multiplicity of shafts, this advantage is lessened.	The saving of weight by using gearing will, however, not be a very large percentage of the total machinery weight, probably not more than 1 or 2 per cent. However, considerable weight in piping is saved by means of the electric drive, so that for large vessels the weight of machinery is about the same for either gearing or for electric drive.
Space	
The advantage will rest to a slight extent with gearing, so far as the cubical contents are concerned.	The space can, however, be in many cases more advantageously utilized. The generator can be placed at some distance from the motor. The shaft can be greatly shortened. This advantage shows up specially on large vessels. Superior boiler-room arrangements can be utilized.
Racing	
The gear and turbine will be subject to the racing action of the propeller.	There will be no racing. The motor will govern the propeller and maintain even speed. This fact may possibly produce a slight gain in propulsive efficiency.
Handling	
Handling is satisfactory.	The advantage rests with the electric drive, especially with regard to backing power. See Jour. A.S.N.E., February, 1916, Stopping, Backing and Turning Ships, by Lieut. S. M. Robinson, U. S. N.
Adaptability to Best Conditions for Efficient Propulsion	
The gear ratio having been adopted it can not be changed. If the effective horsepower and propeller efficiency have not been accurately estimated, an improper ratio will be present which may prevent the turbine from securing its most efficient speed. Unless very high gear ratios are employed the most economical turbines can not be used.	The relative speed of propeller and turbine can be altered to any extent. The turbine can therefore run at its most efficient speed without reference to the propeller speed. This enables a very-high-speed turbine to be used, which allows of greater economy. The design can utilize the very best propeller conditions without affecting the design or limitations of the turbine.
Facility for Repair	
No special advantage. Whole engine plant has to be run when under way. At present large gears can only be cut by very few firms.	In case of accident generator and motor parts can be renewed more easily than gear can be repaired. One generator can be repaired while other works to full power. This will give about three-quarter-speed.

REPAIRS TO BE EXPECTED

Repairs to gearing will be little or nothing; but if damaged to any extent, however, gear will have to be replaced. A spare gear should be at hand to replace one damaged by accident.	The repairs to generator and motor may be of considerably greater extent and may cost more than those to gear, but they can be more readily made, and actual experience with the *Jupiter* does not indicate that there will be large repair bills.

ECONOMY

With the same boilers and turbines gearing has an advantage of about 5 per cent at full power. The same turbines may, however, not be feasible, since the turbine to be used must accommodate itself to the gear that is being used.	Owing to ability to use only one generator at below half power, the ability to run generator at practically constant speed and the flexibility of the electric bond to adjust itself to any speed ratio, it is likely that the initial advantage of gearing in economy will disappear at cruising speeds, and at low speeds the electric drive will be more economical.

REVERSIBILITY—BACKING POWER

Requires a backing turbine, which complicates design and enables only a portion of full power to be used for backing. Limited to about 50 per cent backing power, even with very large backing turbines.	Full backing power is secured without disturbing turbine. Reversing is made particularly easy, and the full utilization of the steam supply is possible for backing, since there is about the same engine efficiency backing as going ahead.

CARE IN OPERATION

Little or no special care required for the gear. Oil supply the essential matter. Some difficulty in lubrication has been experienced.	Considerable attention will have to be given to maintaining generator and motor in condition. This also requires a special knowledge of electrical features, for which personnel will have to be specially trained. Ventilation of motor and keeping it dry will require special attention.

FACILITY FOR INSTALLATION

Location of turbines and gear fixed by position of shaft.	Generators can be located anywhere without regard to shaft. Best location of condenser, steam piping, etc., can be secured. This enables a more more adaptable and simple arrangement to be made. Special advantage of this may be taken in making best provision for torpedo protection.

CERTAINTY OF DATA ON WHICH TO BASE DESIGN

Gears suitable for very large power have not yet been built in this country. Each installation practically necessitates a new design of the gear. Existing installations have been generally successful, but some trouble with wear on gear and breaking of gears has been experienced.	All portions of the electric drive apparatus have been built and fully tested out. They have been applied to one marine installation and have been successful.

The Ljungström turbo-dynamos are a new feature in marine electric driving, but though there has been an installation actually built, the device is still experimental. If it stands up in service it will be a means of improving the now accepted type of electric drive in this country by about 10 per cent. Nothing definite has been done with this device in the U. S., though a great increase in economy is claimed for it and has been secured in numerous actual installations.

BOILER EFFICIENCY

The campaign for economy also makes it necessary to inquire into possible ways of improving boiler economy. Boiler efficiency has remained approximately at a standstill for quite a number of years, but the advent of oil burning has given a new phase to the situation. By means of improved burners continual improvement in combustion has been effected. A great deal of experimental work has been done by the fuel-oil testing plant at the Navy Yard, Philadelphia, and marked improvement in burners has been secured.

It is believed, however, that we are about to secure a material improvement by arranging the heating surface of boilers so as to secure a proper relation between the flow of gases and the circulation of water. The actual course of circulation in water-tube boilers is a matter that bears study and investigation. A recent disclosure has shown that some generally accepted ideas are in error. It is believed that to obtain the best efficiency the gases must be so directed as to pass in the counter direction to the flow of water in the tubes, and that as the gases are cooled and the volume reduced the area of the gas passage should be decreased in order that the velocity of the gases may be maintained at a proper point for the requisite efficiency. Some experiments along these lines are under way.

The best boiler results that we have record of give from 77 to 81 per cent efficiency for well-baffled straight-tube boilers (with 0.1 to 0.3 lb. oil per sq. ft. of heating surface), and about 70 to 78 per cent for express boilers. With coal the boiler efficiency averages about 5 per cent less. It is believed that by special care based on proper experimental data a boiler efficiency of 85 per cent can be secured for continuous operation on board ship; this economy to be effected by means of proper baffling and proper relation of baffling to boiler circulation, and by supplying more efficient clothing and lagging. An oil furnace means a higher furnace temperature, and hence more boiler clothing is needed.

SPECIAL CONDITIONS OF DESIGN

The demands upon the engineer to secure in the new designs the necessary power for a great increase in speed, as well as for special and unprecedented protection from torpedo attack, have made it necessary to get every bit of power out of every pound of weight and cubic foot of space allowed. Everything non-essential must be left off, and every part must be designed to be adequate but without excessive margin. The principal method of saving both weight and space is to install machinery that will secure the highest practical economy, and in searching for the means of accomplishing this the naval engineer is looking to the engineering talent of the country to come to his assistance.

NEW DEVELOPMENTS IN NAVAL ENGINEERING

The present time is especially a period of development in naval engineering. The European war, and the developments caused by it, have emphasized and will tend to emphasize many new features and point out special lines of advancement in naval engineering. We are now almost at the stage of dis-

carding the reciprocating engine and the direct turbine drive for new fighting craft, and in their place are coming turbine reduction gear and the electric drive, with the oil engine for submarines and as a possibility for some auxiliary vessels. Coal burning is being superseded by oil burning on nearly all classes of vessels building for our Navy. There have been recently successfully tried three superdreadnoughts, the *Nevada*, *Oklahoma* and *Pennsylvania*, all of them equipped with oil-burning boilers exclusively. This marks a special step of progress in the evolution of naval engineering work, and the use of oil fuel has permitted many engineering and operating advantages to be secured. Special development is taking place in the field of aeronautical apparatus, and a great deal of this is being done by the coöperation between the Navy and the engineering industries of the country. Many new developments of condensing apparatus, pumps and other auxiliaries are coming on. New things are dawning all the time, and as fast as they give promise of practicability, reliability and proper adaptation to naval use they are tried out and adopted. There is continual progress toward greater efficiency, greater economy, compactness, and in reduction of weight, which enables the United States to take the lead in engineering development. Such developments are largely the result of coöperation between the industrial engineers and the naval engineers. Further to develop this, more experimental and laboratory work is necessary, and the country must be willing to spend some money for experimentation in order to save in actual service, and to secure greater efficiency.

The Navy has now in service one destroyer, one destroyer tender and one submarine tender equipped with Parsons turbine reduction gear, and one collier equipped with Westinghouse reduction gear. There are building four destroyers with machinery of this type, three with Parsons turbines and one with Curtis. Geared cruising turbines are being used on fifteen destroyers and five battleships built and building. The electric drive has been tested out on one auxiliary vessel and is being installed on three first-class battleships building. In the matter of electric drive for propulsion of ships our Navy is the pioneer. This is entirely an American development, and the men responsible for its initiative and its development to a successful point are all Americans. The Navy Department has materially assisted in this development. An experimental Diesel engine, the largest yet to be installed on a vessel, has been completed at the Navy Yard, New York, and is now being installed on the oil-fuel carrier *Maumee*, which has been towed there from San Francisco. This two-cycle Diesel engine, of 5200 h.p., was built by the Government. The tender *Fulton* has been equipped with a two-cycle Diesel engine and has been in service for over a year.

Among the new things in the auxiliary machinery of naval vessels, it may be mentioned that the small steam turbine has been developed as the accepted drive for forced-draft blowers on nearly all our naval vessels. In this also the United States has been the pioneer. The use of gearing for turbine-driven generators, pumps and blowers has also been initiated. Rotary pumps are now being used for oil-fuel service.

Condensers.—The principal improvement in condenser practice has been the adoption of expanded tubes in place of packed tubes. Expanded tubes can be kept absolutely tight, while there is always some doubt about a packed tube. For some years expanded tubes have been used on destroyers. For large vessels the tubes have been expanded at inlet end and packed at outlet end. This prevents crawling of tubes.

Augmenters, dual air pumps, or some kind of dry vacuum apparatus are installed. Tube spacing to allow of least possible resistance to flow of steam is being employed.

Steam ejectors in combination with a condensate pump have been experimented with and their use is being considered. These ejectors save a great deal of weight and space, but they will have to be thoroughly tried out before they can be generally applied.

The importance of high vacuum is fully appreciated and no effort is spared to obtain all possible advantage within the limitations of the design. On turbine vessels the design contemplates securing a vacuum of about 28 to 28½ in. of mercury at full power, with circulating water at 70 deg. fahr. At lower powers a better vacuum is obtained. On destroyers and scouts scoop injection condensers are being used, with a small auxiliary circulating pump to furnish circulating water for backing and while vessel is standing still or maneuvering.

Feed Pumps.—Turbine-driven multiple-stage centrifugal feed pumps are being installed on our latest vessels. It is expected that these pumps will be more reliable, furnish a more steady pressure, and be considerably more economical, especially in repairs, than the reciprocating plunger pumps that they supersede. It is also expected that the centrifugal pumps will require far less overhaul and will lessen the danger of rupturing feed piping.

Rotary Pumps are being adopted for fuel oil service. These pumps give a more steady pressure.

CO_2 *Refrigerating Machines* are being used in place of dense-air ice machines. Some of the later machines are electrically driven, but there is no very special advantage in the electric drive. Small electrically driven refrigerating machines of several types have been developed for use on destroyers and small craft, these being similar to machines used in yachts and private houses.

Distilling Plants of multiple-effect, low-pressure (operating under a vacuum), non-scaling type are being fitted, and auxiliary exhaust is being extensively used for operating evaporators. These steps have resulted in materially reducing the fuel consumption in port. The use of feed heating in connection with distilling plants is being extended and consequent gain in economy realized.

Clutches for connecting or disconnecting cruising units or motors while shafts are revolving, have been experimented with and installed in a number of vessels; some are hydraulic oil clutches, others magnetic. A thoroughly reliable clutch for this service is very desirable, and from the different kinds tried it is hoped that several will be developed beyond the experimental state in the near future. The clutches used are the Metten clutch, operated by oil pressure, the Turner mechanical clutch, and the magnetic clutch manufactured by the Cutler-Hammer Co.

Forced-Draft Blowers.—Tests and experiments have been carried on for several years in order to develop forced-draft fans for destroyers that will be both strong and durable, and which will operate as noiselessly as possible. This is an extremely important matter, as the noise of these fans is one of the things that will disclose the presence of a destroyer to an enemy; it also indicates lack of efficiency.

The Gyroscope, besides its entirely successful application in the gyroscopic compass, which is now installed on all naval vessels of fighting value and which has made submarine navigation practical and reliable, is also being used in numerous other fields, such as a stabilizer for air craft, submarines and for other naval craft.

Radio Apparatus.—In the field of radio development tre-

mendous strides are being made. The range of apparatus on naval vessels has been doubled. Trans-Pacific stations are being built to connect the radio chain across the Pacific from San Diego to Cavite *via* Pearl Harbor. The wireless telephone is also being developed in conjunction with the radio stations.

STANDARDIZATION OF ENGINEERING APPARATUS

Another vital matter involving naval engineering preparedness is the standardization of engineering methods, tools, gages, fittings, parts, etc. Comparatively little has been done in this matter, and the difficulty seems to be to get someone or somebody to start things. The American Society of Mechanical Engineers and other engineering societies have labored in this field, but definite progress is not satisfactory.

Standardization of mechanical apparatus is essential to the maximum efficiency of the naval engineer. Whenever standardized commercial articles can be used the Department is desirous of so doing, as a standard commercial article is (1) more quickly obtained; (2) allows increased competition; (3) will be cheaper; (4) will necessitate carrying a smaller stock of material; (5) and can be obtained readily when away from the source of supply.

Steps towards standardization have been made along the following lines: (1) Boiler-tube specifications of the American Society for Testing Materials, The American Society of Mechanical Engineers, and Railway Master Mechanics' Association are recognized by law in several of the states; (2) Spark plugs for gas engines are fast coming to a standard size with a standard screw thread.

The Navy Department has always been in favor of standardizing mechanical apparatus, and of late years we are trying hard to fix matters so that the best commercial practice in any field will be suitable for naval work. Standardization in many particulars is essential, and the manufacturers and mechanical engineers of the country should be making special effort to secure further standardization of methods, tools and parts. In the end the engineering industry of the country will benefit by this standardization, and engineering material and apparatus can be more economically supplied.

COÖPERATION OF ENGINEERING ACTIVITIES

The naval engineer, both in and out of the service, has many new and interesting problems before him, and it behooves him to be looking to the future to employ the best that science and mechanical ability can provide for fashioning the weapons of naval preparedness. The best development of naval engineering matters will be accelerated by the best possible coöperation between the naval and the industrial engineering talent of the country. Without this hearty coöperation and the support of the engineering facilities of the country, the Navy could not be properly placed or kept upon a war footing. In fact, without the utilization of the civilian engineering talent of the country we would not get very far with our material for the Navy. The Navy appreciates the need of this coöperation, and desires that our commercial engineering forces coöperate in every possible way to give it the best material that American engineering talent can devise and that its mechanical forces can fabricate.

But not only should there be coördination between the civilian engineer and the engineer in the Navy, but there must also be that coöperation and standardization of engineering means and efforts that this Society aims to foster and in which it has been so markedly successful.

A new type of Humphrey pump, built in small sizes, utilizes the oscillations of a heavy weight instead of a column of water.

On the initiative of the Royal Society a Board of Scientific Societies has been established in England to promote the coöperation of those interested in pure or applied science; to supply a means by which the scientific opinion of the country may, on matters relating to science, industry and education, find effective expression; to take such action as may be necessary to promote the application of science to the nation's industries and to its service; and to discuss scientific questions in which international coöperation seems advisable. The board at present consists of representatives of 27 scientific, including technical, societies.

The term "yield point" does not appear to have any fixed meaning, according to J. E. Howard, in a discussion of a paper read before the American Society for Testing Materials, and in his opinion there seems to be no feature in the behavior of steel which calls for this term, or to which it can properly apply. The term is essentially vague and uncertain, and well calculated to create confusion. It is an approximation to the elastic limit, but having been given a name it purports to have a definite meaning. The most that can be said about it is that a structural member loaded up to its yield point will suffer a certain amount of permanent strain.

In steel coal hoppers, filled as they are almost all the time with moist coal, the corrosion of the metal is quite rapid. To prevent this, according to the *Electrical World* (Aug. 19, 1916), it is the practice of the Commonwealth Edison Company (Chicago) to line the hoppers with cement, as follows: After removing any rust from the metal the steel is painted with rust-resisting paint and wire mesh fastened in place. Cement is then applied by spray or by a cement gun, under an air pressure between 40 and 60 lb. per sq. in., and is hydrated before emerging from the nozzle by water coming through a separate hose. The lining thus applied is about 3½ in. in thickness and offers a smooth surface not easily abraded and which protects the steel from the deteriorating influence of the moist fuel.

The lifting capacity of a lifting magnet depends entirely on the materials which it has to handle, particularly, however, on (*a*) the magnetic quality of the load; (*b*) the temperature of the material, which should not be above black heat; (*c*) the shape of the load and whether it consists of one solid piece or a number of small parts; and (*d*) the manner in which the material to be lifted is stacked. Although the lifting capacity cannot be calculated, it may be assumed that a well-designed magnet is capable of lifting a solid piece of steel, with machined surface, of not less diameter than the magnet itself, weighing approximately 15 times the weight of small magnets, 8 to 12 times the weight of magnets from 24 to 36 in. in diameter, and 5 to 6 times the weight of magnets from 36 to 60 in. in diameter.—*The Electrician*, Aug. 11, 1916.

STEAM-FLOW MEASUREMENT

A Statement of the Problem of Steam Metering to Determine Boiler Output or Prime Mover Capacity, and a Description of an Experimentally Developed Meter of the Orifice Type

By ERVIN G. BAILEY, BOSTON, MASS.

Member of the Society

THE accurate measurement of the flow of fluids is one of the most important problems facing the mechanical engineer today. The turbine, boiler and mechanical stoker have been materially improved in their design both as to size and efficiency, but much still depends upon the method of operating these large units. The operating engineer cannot get results when working in the dark; he particularly needs to know the steam output from the boilers, the condition of the fuel bed, the air supply to the furnaces and the steam consumption of the turbines. Methods of determining the kilowatt output of the latter have been in satisfactory use for a number of years. Electricity is comparatively easy to measure, and we find the switchboard supplied with all kinds of instruments for this purpose. There is just as much need for the corresponding measurements of the flow of steam and gases.

METHODS OF MEASURING PRESSURE DIFFERENCE

It is desirable to go a step further than merely to measure these rates of flow, and show in addition the relation between two or more interdependent quantities which enter into the operation of a steam boiler or prime mover. Seven years of experimenting, which involved the use of more than fifty steam-generating or steam-using units, have produced many interesting results along this line, but the present paper will be confined to the measurement of steam flow, as this is really the crux of the whole question. Few problems have been more baffling to the mechanical engineer than the accurate metering of steam in large quantities. It is necessary to use the "flow" principle; that is, to produce a pressure difference which varies in a definite and known relation to the rate of flow, and then to measure accurately this pressure difference in terms of weight of steam.

There are only two fundamental principles that have been used to obtain the pressure difference, *viz.*, "impact" and "change in velocity." The "impact" principle is used in the pitot tube with its various modifications, and the Vortex[1] and Metering Bend[2] also belong to this class. The "change in velocity" type covers the venturi tube and the orifice.

We do not usually think of the orifice as being of the same basic principle as the venturi tube, but the two are practically identical when the orifice is used in a pipe and the pressure connections are made at the proper place. The pressure difference produced in both cases is caused by the increased velocity and the corresponding change in the static pressure between two different positions along the pipe where the flowing stream has different areas. The exact area and location of the smallest section of the stream on the downstream side of an orifice may not be quite as tangible a thing to see and measure as is the throat of a venturi tube, to which it corresponds; but experiments have proven that it is none the less a perfectly dependable function of the opening in the orifice plate. With high initial velocities the pressure difference is largely restored in static pressure within four pipe diameters beyond the orifice, so that the net loss in head caused by the orifice may not be more than 25 per cent of the head available. This compares very favorably with the best design of venturi tube, where the net loss is about 15 per cent of the total venturi head.

Pitot-tube and multi-hole nozzles of various designs and

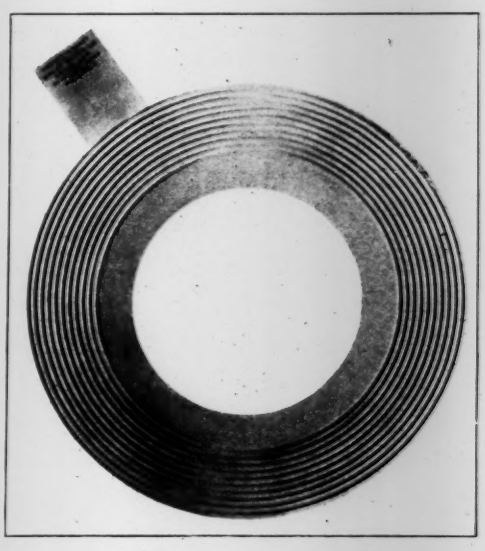

FIG. 1 INITIAL DESIGN OF ORIFICE PLATE

modifications were used exclusively during the first two years of experiment, but were entirely abandoned for reasons explained later. The venturi tube was at first considered to be the only available substitute, but the expense of changing large steam pipes, in addition to the cost of the tube itself, made this prohibitive for very general use. The orifice was taken up and the following important points were considered in working out a suitable design:

1 The orifice plate must go in between a pair of existing pipe flanges.
2 It should not thicken the joint so as to throw the flanges out of parallel.
3 The metal used should perfectly withstand all corrosion and abrasion.
4 It should be capable of easy installation.

TYPE OF ORIFICE ADOPTED

The initial design shown in Fig. 1 consisted of a $^1/_{32}$-in. Monel metal plate having corrugations on its outer edge to

[1] A Rate Flow Meter, H. C. Hayes, Trans. Am.Soc.M.E., vol. 36, 1914.
[2] A Flow Metering Apparatus, A. M. Levin, Trans. Am.Soc.M.E., vol. 36, 1914.

Presented at a meeting of the Boston Section of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS, May 23, 1916.

make its own packing the same as a corrugated copper gasket, and having a round concentric hole smaller than the pipe diameter. But what coefficient to allow in calculating the size of the orifice for a given pipe diameter, steam density and rate of flow, was the big unknown. The importance of testing the orifice to see if it would maintain a constant factor over long periods of time was of more importance than to know the exact factors under all conditions, consequently some guesses as to the coefficient were made and several orifices were put into experimental use in places where the service was continuous and severe.

It may seem that the early experimenting could have been done with most anything and a satisfactory design worked out later, but too often some practical consideration necessitates a decided change in design which upsets all the previous results. It is much better to get a good working design and learn whether the device will keep on working and maintain its accuracy, before any extensive scientific tests are made to learn definitely what physical laws are involved in its use.

One of the first orifices of this type was put into a 15-in. pipe supplying steam at 200 lb. pressure and 150 deg. superheat to a 15,000-kw. turbine in the L St. Station of the Edison Electric Illuminating Company of Boston, where the rate of flow averages more than 150,000 lb. of steam per hour. The

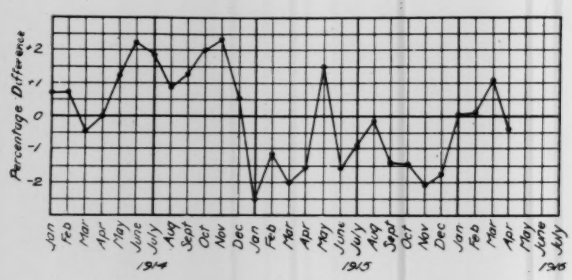
Percentage Difference
+2
+1
0
-1
-2
Jan Feb Mar Apr May June July Aug Sept Oct Nov Dec Jan Feb Mar Apr May June July Aug Sept Oct Nov Dec Jan Feb Mar Apr May June July
1914
1915
1916

FIG. 2 COMPARISON OF STEAM METER READINGS AND ACTUAL WEIGHTS OF STEAM

Abscissas give percentage differences in meter readings from actual weights

only flange available was at the inlet to the turbine strainer, about 6 ft. (or five pipe diameters) beyond a 90-deg. bend of 6 ft. radius. The Testing Department of the Edison Company have made weighed water-rate tests of this turbine each month since this orifice was installed in December, 1913, and results from this orifice have been obtained at the same time.

DATA OF TESTS ON EXPERIMENTAL ORIFICE METER

The substance of these tests is given in Table 1, and the percentage differences between the weights and orifice-meter results are plotted in Fig. 2. It is noted that there are 28 tests extending over more than two years, and that approximately 1,000,000 tons of steam have passed through the orifice in this period. It is also noted that the greatest difference is 2.51 per cent, and that the majority of them are within 1 per cent. The device for measuring this pressure difference was not of the latest and best design.

It is shown conclusively that there is no appreciable change in the orifice factor over this period. This is also borne out by the measurement and appearance of orifice plates replaced by others of larger capacity after a year or more of service, none of which shows any corrosion or wear whatever.

The main object of the Edison tests is to determine the water rate of the turbine, the orifice data being secondary, and it is customary to make all tests at approximately the same load, but this does not detract from the value of these results in proving the continued accuracy of the orifice over long periods of time.

Other orifices were put in from time to time under various conditions where weighed-water calibration data could be obtained at capacities most frequently met in practice. The coefficient of discharge did not appear to be as constant for different ratios of orifice to pipe diameter as it had been hoped that it would. The indications were that the orifice was fundamentally correct, and the discrepancies encountered were only through lack of sufficient knowledge relating to details. The general trend of the data up to this point was that the coefficient of discharge increased with an increase in the ratio of orifice diameter to pipe diameter, with no obvious reason why it should. In cases where the area of the orifice is large compared with the area of the pipe, the velocity of approach is an important factor, but even taking this into consideration, the net coefficient of discharge increased with the orifice area. This same fact has since been brought out by Hickstein,[1] who practically followed the results obtained in Charlottenburg[2]

TABLE 1 STEAM MEASUREMENTS WITH AN ORIFICE-TYPE FLOW METER

Results from a meter measuring steam to a 15000-kw. turbine in the L Street Station of the Edison Electric Illuminating Company of Boston. This meter has a maximum capacity of over 200,000 lb. per hour, and is provided with a Monel metal orifice placed in the inlet flange of the turbine strainer about 6 ft. beyond a 90 deg. bend in a 15-in. pipe. Meter readings were taken in conjunction with the regular monthly turbine water-rate tests by the company's testing department.

Date	Duration of test	Steam pressure by gage, lb.	Superheat, deg. fahr.	Condensed steam per hour as weighed, lb.	Steam per hour by orifice meter, lb.	Difference between meter and weight, per cent
1/ 8/14	1 hr.	196.5	129.6	133,417	134,372	+0.72
21 6/14	1 hr.	191.3	152.2	137,739	138,756	+0.74
3/28/14	55 min.	200.1	128.4	136,763	138,163	−0.44
4/23/14	1 hr.	190.7	135.4	136,332	136,366	+0.02
5/14/14	1 hr.	193.1	149.0	132,610	134,299	+1.27
6/12/14	35 min.	196.5	134.1	135,421	138,495	+2.27
7/ 9/14	1 hr.	191.3	128.8	138,740	141,300	+1.85
8/15/14	1 hr.	194.2	130.8	142,065	143,235	+0.84
9/10/14	1 hr.	197.0	129.3	136,846	138,606	+1.29
10/20/14	1 hr.	197.5	138.2	137,003	139,723	+1.99
11/21/14	1 hr.	193.9	140.8	132,552	135,631	+2.32
12/19/14	1 hr.	196.0	146.2	129,759	130,454	+0.54
1/22/15	1 hr.	198.0	152.1	131,134	127,845	−2.51
2/19/15	1 hr.	195.2	163.7	129,165	127,641	−1.18
3/18/15	1 hr.	193.0	168.3	128,917	126,317	−2.02
4/24/15	40 min.	195.0	158.5	132,017	129,856	−1.56
5/20/15	1 hr.	197.4	158.6	132,107	134,120	+1.52
6/22/15	1 hr.	193.5	145.8	140,582	138,340	−1.59
7/20/15	1 hr.	192.8	141.2	138,457	137,110	−0.97
8/19/15	1 hr.	192.6	141.5	139,200	138,975	−0.16
9/23/15	1 hr.	196.8	143.0	139,385	137,399	−1.42
10/27/15	1 hr.	195.0	142.3	137,504	135,472	−1.48
11/19/15	1 hr.	193.8	152.1	137,397	134,528	−2.09
12/ 7/15	1 hr.	196.1	154.2	131,466	129,205	−1.72
1/18/16	1 hr.	196.0	152.2	130,526	130,610	+0.06
2/11/16	1 hr.	194.1	141.3	131,812	132,001	+0.14
3/14/16	1 hr.	195.2	171.4	129,030	130,391	+1.05
4/13/16	80 min.	189.4	144.2	137,472	136,945	−0.38

[1] The Flow of Air Through Thin-Plate Orifices, Trans. Am.Soc.M.E., vol. 37, p. 765.

[2] Zeit. d. Ver. deutsch. Ing., Feb. 22, 1908.

some years ago. These two experiments dealt with natural gas and air only, and unfortunately the pressure connections were located at such great distances from the orifice plate that they could not possibly be duplicated in but very few steam pipes, where there were long straight runs.

LOCATION OF PRESSURE CONNECTIONS

The question which came up in this problem, that had never been thoroughly investigated to our knowledge, was the location of the pressure connections on the upstream and downstream sides of the orifice. It was felt that this was a point which should be thorougly investigated, consequently, at the

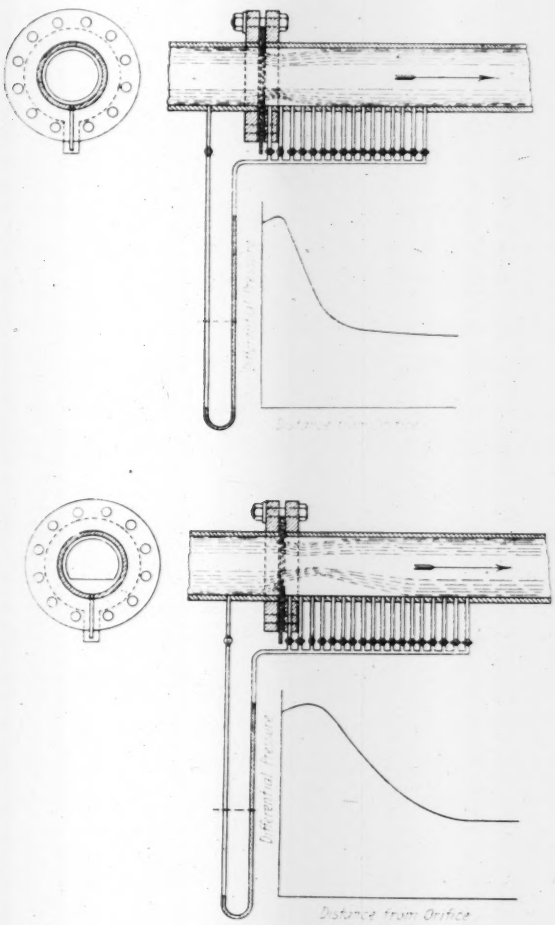

FIG. 3 EFFECT OF LOCATION OF PRESSURE CONNECTIONS

writer's suggestion, Professor Judd of Ohio State University started some experimental work along this line and some of his results were presented in a paper at the New Orleans Meeting of this year under the title of Experiments on Water Flow Through Pipe Orifices.

The important points brought out by Mr. Judd's data are:

1 The coefficients of the orifices tested are substantially constant at all rates of flow for any one set of pressure connections, regardless of their location with respect to the orifice plate.

2 The location of the pressure connections is of vital importance with the higher ratios of orifice to pipe diameter with round concentric orifices, due to the restoration of static pressure.

3 The use of specially designed orifices of other shapes than round and concentric permits the downstream connection to be far enough away to clear any flange, and also allows more latitude in the location of this connection without endangering the accuracy.

The last two points are clearly illustrated in Fig. 3, which shows a diagrammatic arrangement of the experiment and the plotted curve representing the pressure difference as measured between the upstream connections and the several downstream connections located at ½-in. intervals from the orifice plate. It is evident from the round concentric orifice of rela-

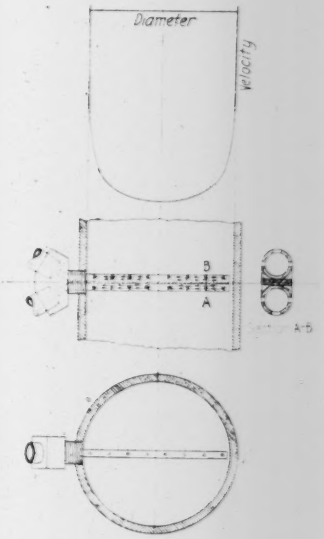

FIG. 4 EXPERIMENTAL MULTI-HOLE NOZZLE WITH SIDE OUTLETS

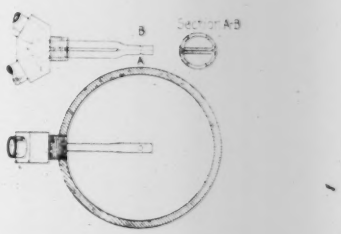

FIG. 5 SINGLE-HOLE NOZZLE

tively large diameter in the upper view of Fig. 3 that the action of the fluid on the downstream side of the orifice is practically identical with that in the venturi tube. The point of highest velocity is at the "vena contracta" just beyond the orifice plate, and the static pressure is the least and the pressure difference the greatest at this point which corresponds to the throat of the venturi tube. The active stream expands beyond this point, and as its velocity is thereby reduced the static pressure is partially restored and the pressure difference correspondingly diminished. As high as 77 per cent of the pressure difference is restored in some cases.

It seems that the orifice acts merely as a forming tool to direct the active stream into a natural venturi shape, and at the same time gives just as dependable results. In fact, it appears to give more dependable readings than a venturi tube when placed close beyond or in front of bends or other disturbances. Similar orifices put in under the conditions given

below gave the same coefficient within 1 per cent when calibrated by actual weight tests.

CONDITIONS OF ORIFICE INSTALLATIONS GIVING SAME COEFFICIENT WITHIN 1 PER CENT

Size of Pipe, In.	Fluid Measured	Straight Run on Upstream Side, Pipe Diam.	Conditions on Upstream Side of Straight Run	Straight Run on Downstream Side, Pipe Diam.	Conditions on Downstream Side of Straight Run
15	Steam	5	90 deg. bend	none	Turbine strainer
8	Steam	1½	90 deg. bend	none	Turbine strainer
6	Steam	3	90 deg. bend	none	Gate valve
6	Steam	20	Gate and globe valve	20	Orifice
5	Water	59	Elbow	56	Orifice
4	Steam	6	Outlet of 4-in. tee	none	Gate valve

UNSUITABILITY OF PITOT TUBES AND NOZZLES FOR MEASURING THE FLOW OF SWIRLING FLUID

The writer believes that a helical or corkscrew motion of the fluid following a bend or similar disturbance is very common and prevents any satisfactory results being obtained from

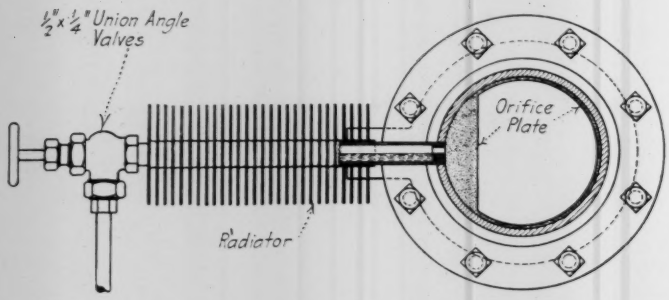

FIG. 6 SEGMENTAL ORIFICE AND RADIATOR IN HORIZONTAL PIPE

the use of pitot tubes, multi-hole nozzles, or venturi tubes, while the orifice seems to give the same coefficient as if in a long straight run of pipe. To illustrate this the following interesting experience is given:

It was desired to measure the steam output from some 250-h.p. boilers having 8-in. steam outlets which gave a very low steam velocity. The boilers were standard two-drum Babcock and Wilcox with the 8-in. pipe rising from the manifold with a 90-deg. bend and then about 3 ft. of straight horizontal run into a gate valve adjacent to the header. At first a multi-hole nozzle similar to that shown in Fig. 4 was located about 1 ft. in front of the gate valve, and upon calibration it was found that the reading was about 15 per cent lower than would be expected. At first it was assumed that the highest velocity was not in the center of the pipe, but was shooting above the nozzle as a result of the 90-deg. bend. Traverse work in steam pipes from boilers was not attempted, owing to the fluctuating rate of steam flow and the difficulty of handling adjustable tubes in high-pressure steam lines. A single-hole nozzle like that shown in Fig. 5 was then tried, and a rather unexpected set of results obtained; for during the night time, when the load on the boiler was very light, it was found that this nozzle gave very nearly the same factor as applies to a long straight run of pipe, but as soon as the load came on in the morning, instead of the steam-flow pen starting up, it would drop. If the load was sufficiently increased it would come back to the same reading given on the night load, or a little higher, but never did it go anywhere near as high as it should. Some calibration work under the heavy-load conditions showed that this single-hole nozzle gave results as much as 85 per cent low.

In seeking an explanation all available literature on the subject was examined, and it was found that the paper of Gregory and Schoder[1] gave practically the only data pertaining to traverses of pipe lines in and near a bend. Some very peculiar flow curves were shown in this paper with practically no comment, but by plotting these flow curves on pieces of paper and pasting them at right angles to each other as the traverses were made and stringing them on a bent wire, it was very

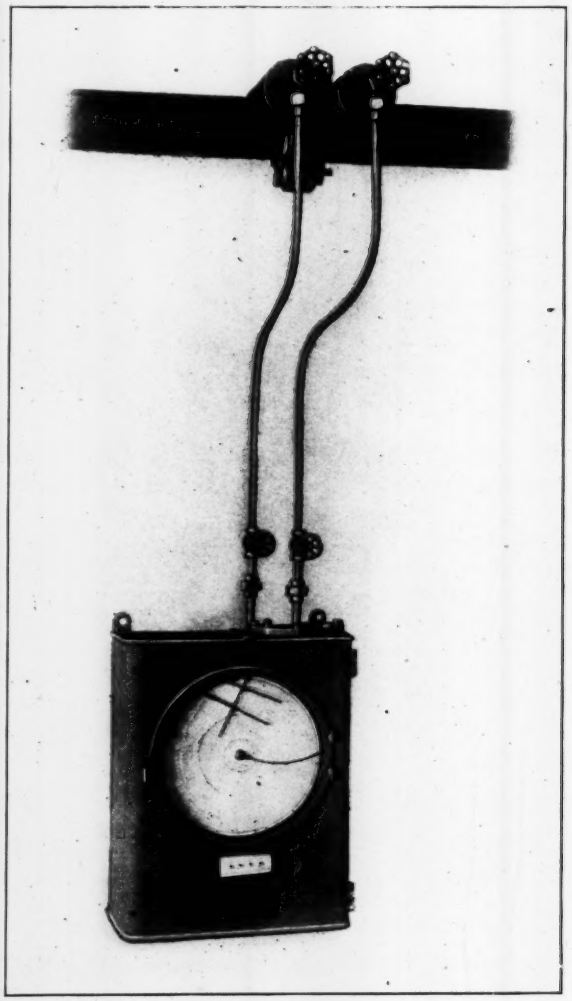

FIG. 7 BAILEY FLUID METER

evident that a swirling motion was taking place, which resulted in a higher velocity near the circumference of the pipe than existed in the center. This coincided with our experience, because the single-hole nozzle showed the velocity in the center of the pipe to be normal at low velocities, but very much below normal at velocities which might be expected to produce the helical motion.

To prove this beyond doubt, the next step was to put in a single-hole nozzle, or the equivalent to a pitot tube, with the openings near the circumference of the pipe. This was done, and it was found that a very high velocity existed within ½

[1] Some Pitot Tube Studies. Trans. Am.Soc.M.E., vol. 30, 1908.

in. of the circumference of the pipe when the boiler was steaming at 50 per cent or more of its rated capacity.

This experience killed all faith in the pitot tube and any other type of nozzle for use in steam pipes where there was any possibility of helical or swirling motion. Orifices were installed in these boiler connections at the inlet to the gate valves with very accurate and satisfactory results.

The gradual contraction at the inlet to a venturi tube would have no tendency to destroy the helical motion, and its angular velocity would be greatly accelerated in the throat, thereby producing a centrifugal force against the piezometer holes and giving an erroneous pressure difference. The more sudden contraction in the orifice and its downstream pressure connection being entirely away from the active stream, are undoubtedly responsible for the satisfactory results from its use.

In addition to the fact that the multi-hole nozzle did not give a true average in the instance referred to with the helical motion of steam, it also failed to maintain a constant factor even in long runs of straight pipe. The type of nozzle used in these experiments is shown in Fig. 4. This was made by driving two pieces of $^5/_{16}$-in. phosphor-bronze tubing into a plug having a $^3/_4$-in. pipe thread to be screwed into the side of the steam pipe. Regardless of the size of pipe, the upstream tube was drilled with eight $^3/_{32}$-in. holes, equally spaced across the diameter of the pipe. The downstream tube was drilled in the same manner, so that it got the reverse effect instead of being a true static. The side outlet holes shown were used only for high velocities. The theory of this multi-hole nozzle is not based upon very sound premises, for in the case of a normal flow in a long run of straight pipe with the higher velocity in the center, it is obvious that the dynamic force against the holes near the center of the pipe will be greater than that against the holes near the side, therefore steam will enter the center holes, divide, and run in both directions through the $^5/_{16}$-in. tube and be forced out against the flowing stream through the holes near the side of the pipe. The net result, insofar as pressure or pressure difference is concerned, will therefore be a function of the relative area of these holes as compared with the area and length of the tube in which they are drilled, together with the spacing of the holes along the tube with respect to the diameter of the pipe. Considerable experimenting was done with this type of nozzle in various sizes of pipes, and its coefficient was found to vary between 1.19 and 1.21.

Early in our experience some very high velocities were encountered in the case of 500-h.p. boilers provided with 5-in. steam pipes, as the boilers were frequently operated at 220 per cent or more of their rated capacity. The velocity head that would be produced by the multi-hole nozzle as shown in Fig. 4 with only the upstream and downstream holes would have exceeded 7 in. of mercury, which was beyond the capacity of the recording device being used, and it was therefore necessary to minimize this pressure difference in some way. It was first decided to drill by-pass holes between the upstream and downstream tubes of the nozzle, but this was never tried because the tubes were not always exactly the same distance apart, and in drilling through the spacer and brazing material which filled the space between the tubes, it would give the equivalent of a long tube of small diameter with variable and undetermined length. Therefore the holes were drilled in the sides of both the upstream and downstream tubes, which would be top and bottom in a horizontal pipe. Such a tube is shown in Fig. 4. The size of these outlet holes was varied according to the velocity to be contended with and the pressure difference desired.

A large number of calibrations was made with such multi-hole nozzles in 5-in., 6-in. and 8-in. pipes, with outlet holes varying from a No. 60 drill up to a No. 47 drill, in which case the coefficient was brought down as low as 0.68, as against 1.20 with no side outlet holes.

Continued experiments with these multi-hole nozzles showed their vital weakness to be in a change in coefficient resulting from the accumulation of sediment around the edges of some of the holes, thus reducing their area. In many cases some of the holes were entirely plugged. In some steam pipes this sediment accumulated very rapidly, so that no dependable results could be obtained over any reasonable length of time. Even the simpler types of nozzle, where there were no outlet holes, and only those pointing directly up and down stream, produced the same trouble, for sediment would accumulate around the holes at the radiator end of these tubes and a higher pressure difference was produced due to the relatively

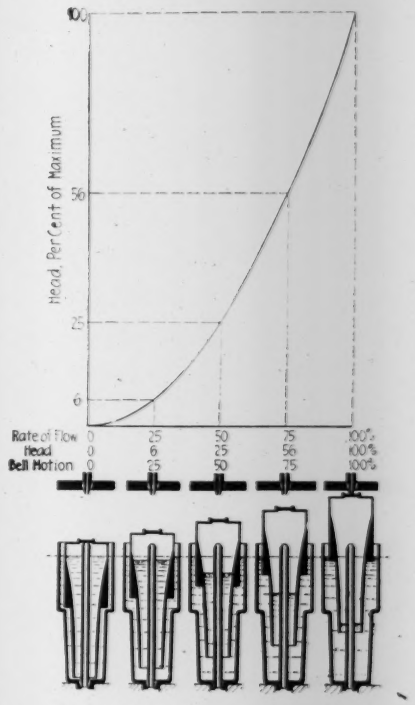

FIG. 8 PRINCIPLE OF LEDOUX LIQUID-SEALED BELL

greater effect of the holes near the center of the pipe. In time the center holes would become partially or completely plugged, in which case the coefficient would again approach normal, and then it would decrease when only the holes in the low-velocity zone at the farther side of the pipe were left open. In the latter case the meter would read low. Larger holes minimized or delayed the change in the factor, but they did not prevent it.

MAINTENANCE OF EQUAL WATER LEVELS IN CONNECTING PIPES

In measuring the comparatively small velocity heads or pressure differences available, it is necessary that the recording instrument casing and the connecting pipes be completely filled with water and its level be maintained equal in both pipes, otherwise a false differential due to the unequal water head will result. At first it was thought best to provide large reservoirs in each connection and on a level with the point where the steam line is tapped, so that any displacement caused

by a movement of the mercury in the U-tube or recorder mechanism, due to a change in the rate of flow, would not materially lower the water level in one reservoir. The equal volume of water that was forced into the other reservoir from the recorder drained back into the steam pipe. This arrangement required excessively large reservoirs to prevent serious lag with a variable rate of flow. It was realized that, regardless of the size of the reservoir, accuracy in following a variable rate of flow was dependent upon the rapidity with which steam could be condensed in the reservoir to replace that which had been drawn out. By providing sufficient radiating surface the size of the reservoir was of secondary importance, so the type of radiator shown in Fig. 6 was tried and found to be very satisfactory. The radiator consists of a piece

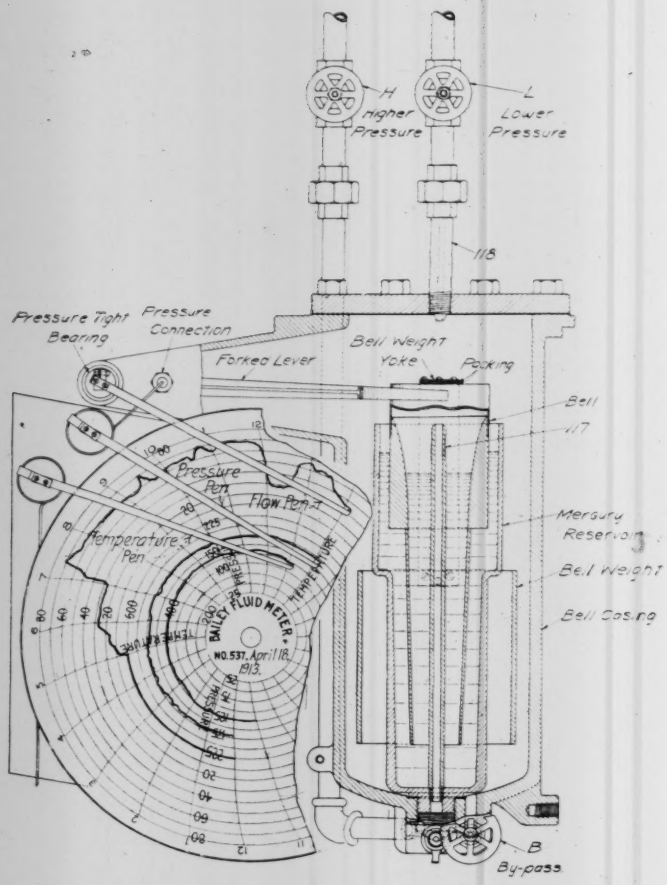

FIG. 9 DIFFERENTIAL PRESSURE RECORDER, LEDOUX BELL TYPE

of ½-in. extra-heavy copper pipe, plugged on the end which is screwed into the steam pipe, with a ¼-in. hole drilled in the top half of the plug. A number of specially designed washers or fins, 4 in. in diameter and $^1/_{16}$ in. thick, are pressed onto the ½-in. pipe and give ample radiating surface to maintain substantially equal water levels in the connecting pipes, regardless of fluctuations in the rate of flow. Fig. 7 shows a pair of these radiators in place on opposite sides of a flange.

The relation between rate of flow and pressure difference substantially follows the $V^2 = 2gh$ law for the orifice as well as the pitot and venturi tubes. This means that for a rate of flow that is 10 per cent of the maximum allowable capacity, the pressure difference available to operate any U-tube indicator or other device is only 1 per cent of the maximum.

THE LEDOUX LIQUID-SEALED BELL FOR MEASURING SMALL PRESSURE DIFFERENCES

Of the three principal methods usually employed to measure small pressure differences, *viz.*, U-tube, diaphragm, and liquid-sealed bell, the latter has been found to be the most satisfactory. It is on the same basic principle as a piston which gives a force proportional to the area times the difference in pressure applied to its opposite sides, but by sealing the walls of the bell in a liquid, instead of confining the piston to a cylinder, it is made substantially frictionless in its operation. Furthermore, by varying the relative cross-sectional area of the bell and its walls, any complex relation between pressure difference and bell motion may be readily obtained.

A very ingenious and thoroughly practicable design for flow-meter work has been described by J. W. Ledoux,[1] member of this Society. This can be briefly explained by referring to Fig. 8, which shows a typical flow curve and a liquid-sealed bell of this type in five different positions corresponding to as many rates of flow equally spaced between zero and 100 per cent, inclusive. In the zero position the bell is held almost completely submerged so that the large effective area and the thin wall are at the surface of the mercury. The increment of pressure difference corresponding to the first appreciable rate of flow is very small, but this is effective over the entire area of the bell, forcing it upward, and as the bell rises its walls emerge from the mercury, changing the buoyant force, thereby exactly counteracting the upward force due to the pressure difference. A rate of flow of 25 per cent corresponds to a head of only 6 per cent, so that the relation between bell area and wall gives a very powerful and magnified motion which is directly proportional to the rate of flow, and therefore amounts to 25 per cent of the total bell motion allowed for in the design. And so on, each step may be followed, showing that the motion of the bell is directly proportional to the rate of flow, and that the device is not only one easy to read and which permits integrating mechanism to be used with a simple design, but one which also has greater power at the lower rates of flow and produces a very satisfactory degree of accuracy. An interesting feature of this bell is that the volume of mercury displaced on its interior side by the difference in level of mercury, exactly equals the volume of the walls in the bell which are forced out from the mercury, so that the mercury level in the containing reservoir is substantially constant. The higher and lower pressure connections terminating within and above the bell respectively are so positioned that a soft packing filler piece will engage and seal either of these when an extreme position is taken. This effectively seals either outlet, and as the entire mechanism is enclosed in a steam-pressure-tight casing and completely filled with water, no mercury can be blown out or the accuracy of the mechanism impaired through excessive pressure differences caused either by abnormal rates of flow, faulty manipulation of the valves, or even the breaking of one of the two pressure connecting pipes. Fig. 9 shows one application of the Ledoux bell to a recorder.

MEASUREMENT OF PULSATING FLOW

The question of measuring steam to reciprocating engines, pumps, etc., has been somewhat misunderstood. Many engineers have the impression that the pulsations cause an unduly fluctuating motion of the recording or integrating mechanism,

[1] A Mechanism for Metering and Recording the Flow of Fluids, etc. Trans. Am.Soc.C.E., vol. 76 (1913).

so that accurate results cannot be secured. But such is not the case except in very-slow-speed pumps. It is also wrong to say that a flow meter is inaccurate for measuring pulsating flow, for the present flow meters will produce accurate results when more knowledge is gained along this line. Steam flowing to a reciprocating engine follows some such variations as are shown in Fig. 10, the exact nature of the curve depending upon the cut-off, capacity of the steam line between the orifice and the engine, and some other factors. At any rate of flow there are very great and frequent variations in the rate of flow which occur periodically and yet so rapidly that no recording meter could possibly follow them individually. In fact, the inertia of the water columns in the connecting pipes to the recorder, together with the mercury in the U-tube, bell float, or other mechanism, is so great that no appreciable motion results from the individual pulsations, but rather the reading is an average of the head or pressure difference resulting from such flow. Regardless of the use of cams, special-shaped bells, displacing members, or any other mechanism whereby a motion is produced in direct proportion to the rate of flow, for continuous flow they cannot possibly produce an average reading that is directly proportional to the rate of flow in the case of pulsating flow.

In Fig. 10 the parabola shows the characteristic relation between rate of flow and pressure difference with 100 per cent flow at 100 per cent head. Assuming that the rate of flow varies from zero to 100 per cent, the nature of the cycle being no flow during 50 per cent of the time and 100 per cent flow during the other 50 per cent of time, then the average flow would be 50 per cent. At the same time the pressure difference varies in like manner from 0 to 50 in. water head, with an average of 25 in. The inertia of the meter mechanism produces a reading corresponding to this average pressure difference of 25 in. instead of an average reading of 50 per cent on the quantity scale. The reading on the quantity scale corresponding to the average head of 25 in. is 70.7 per cent. This 70.7 per cent divided by 50 per cent, which is the true average flow, gives 1.42, or a reading 42 per cent higher than would be the case if the same amount of steam were flowing at a continuous rate. This ratio has been termed the "pulsating factor," and while it might be calculated on a theoretical basis from the nature of the flow curve, if it were known, yet it is better to determine it by actual calibration; and if so determined the steam-flow meter can operate as satisfactorily on a reciprocating engine as on a continuous flow to turbines, heating systems, etc. It should be remembered that the pulsating factor may not be the same at all different loads of the engine. It is, however, a function of the load for any one engine so long as the valve adjustment, etc. remain reasonably uniform.

The problems in connection with pulsating flow that are most difficult are those in which there is a mixture of pulsating and continuous flow, with no definite ratio or relation existing between the two. An example of this would be a steam line supplying both an engine and a turbine. Another case where the pulsating effect has been encountered was in a steam line leading from a main header to a heating system where a reciprocating engine also drew steam from the same header. Even though the orifice of the flow meter was in the branch line leading to the heating system alone, yet the intermittent flow of steam to the engine caused a fluctuation in the steam pressure in the header. This fluctuation in static pressure caused a fluctuation in the rate of flow of steam to the heating system from this header, with the result that an erroneous reading might have been obtained if the meter had not been calibrated under such operating conditions. The pulsating factor may sometimes be eliminated by throttling between the orifice and the source of pulsation.

CALIBRATION OF STEAM-FLOW METERS

It is desirable to have a ready means for calibrating steam-flow meters in place, as it is for wattmeters, pressure gages, thermometers, etc. It has heretofore been considered necessary that steam-flow meters be calibrated by passing all the steam through a turbine to a surface condenser that is known to be tight and free from leaks. This latter point can be well taken care of where sea water is used for circulating, but is often difficult where fresh water is used. The other method is in weighing water to a boiler from which all the steam passes through the meter being calibrated. In this case it is neces-

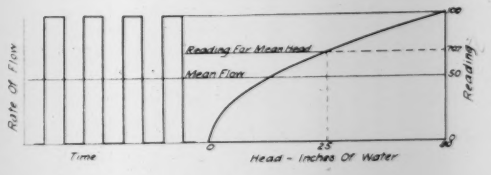

FIG. 10 EFFECT OF PULSATING FLOW

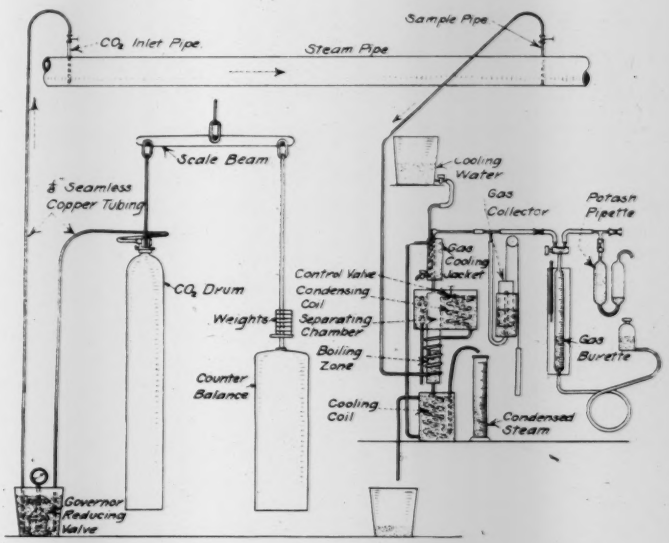

FIG. 11 "CO_2 METHOD" OF STEAM MEASUREMENT

sary to guard against leaks from the feed line, blow-off, or branch steam lines. An additional difficulty arises in the boiler method, which is in having the same amount of water in the boiler at the end as at the beginning of the test. The fact that the water level is brought to the same mark on the gage glass is not positive evidence that the water in both drums or even different parts of the same drum is at the same level. But a still greater source of error along this line lies in the volume of steam beneath the water level, which is greatly affected by the rate of steaming. Some tests on a 500-h.p. Babcock and Wilcox boiler have shown that the volume of steam beneath the water level varies as much as 50 cu. ft. with a change in the rate of steaming of 14,000 lb. per hour. That is, the boiler was steaming at the rate of 24,000 lb. per hour at the beginning of the hour, and at 10,000 lb. per hour at the end of the hour; there were 11,500 lb. of steam generated during the

hour, but it was necessary to feed 14,750 lb. of water to the boiler during this period to maintain the water level at the same point in the gage glass. This means that 3250 lb. of water, or over 50 cu. ft., were required to fill the additional space occupied by steam below the water level at the higher rate of steaming as compared with the lower rate. This is a source of error that cannot be overcome or corrected except by continuing a test over a long period of time and ending the test with the same rate of steaming as at the beginning.

CO_2 METHOD OF STEAM-METER CALIBRATION

In case of weighing water either to a boiler or from a surface condenser, it is necessary to put in large weighing tanks and scales and often make very costly changes in the feed line or steam piping, so that a diligent study of this problem was made to find a better method of steam-meter calibration. The method worked out by the writer consists in introducing CO_2 gas from a high-pressure drum into the steam line at a known and continuous rate, permitting it to mix with the steam, then drawing out a sample, condensing the steam and determining the ratio of condensed steam to CO_2 gas.

TABLE 2 SUMMARY OF DATA COMPARING STEAM MEASUREMENT BY CO_2 METHOD WITH ACTUAL WEIGHT AND STEAM-FLOW METER, ORIFICE TYPE

Made in connection with evaporation tests on a 512-h.p. B. & W. boiler.

Duration of test, hours	Water fed to boiler by actual weight, lb.	CO_2 fed per hr., lb.	Ratio water to CO_2	Steam by CO_2, lb.	Steam by meter, lb.	Difference between CO_2 method and	
						Actual weight, per cent	Steam meter, per cent
4	[1]	8.64	2548	90,500	91,620	.....	− 1.22
2.5	78,515	8.53	3645	77,650	78,040	− 1.10	− 0.50
6	133,474	8.68	2506	130,500	129,190	− 2.26	+1.01
3	54,505	14.63	1276	56,000	55,830	+2.78	+0.29
9[1]	187,979	.....	....	186,500	185,020	− 0.78	+0.80
5	132,667	8.85	2992	132,130	133,650	− 0 40	− 1.14

[1] This line gives the sums of the two runs directly above.

In the first experimental work along this line the attempt was made to determine this ratio by considering the CO_2 as carbonic acid in solution and titrating for the amount of it contained in the condensed steam by the use of chemical means. Some rather erratic and unexpected results were at first obtained from this titration method, and in an effort to check up this method another more valuable feature was worked out whereby the gas was thoroughly separated continuously from the condensed steam and the two measured separately. The general diagrammatic arrangement of the apparatus used in this method is shown in Fig. 11.

This method is based upon the addition of CO_2 gas from a high-pressure tank or drum to the steam line at a continuous and known rate. The gas becomes thoroughly mixed with the steam as it passes along, and a sample consisting of a mixture of steam and CO_2 gas is drawn off continuously from a point further down the line. The steam in the sample is then condensed, the gas and water are thoroughly separated and each measured so as to determine the ratio of water to gas. This ratio multiplied by the rate at which the gas was added will give the rate of flow of steam.

The drum containing CO_2 gas under high pressure is supported on a scale beam so that its weight can be determined at any time, from which the rate of adding the gas is accurately determined. The gas is continuously discharged through a flexible copper tube and a governor valve into the steam line through a ⅛-in. spray tube. A sample of the mixed steam and gas is taken from the steam pipe at a point further down the line. The sample is then passed through a condensing and separating apparatus and the condensed steam and gas are measured separately in a graduate and Hempel burette, respectively. The entire operation is continuous, except that these two measurements are taken simultaneously at regular intervals of four to five minutes.

An accuracy of 1 per cent to 1½ per cent can be secured when using only 1 lb. of gas to 2000 lb. of steam. Hence it is possible to use this method on large capacities up to several hundred thousand pounds of steam per hour. Some data are given in Table 2.

This method has also been tested out for measuring the flow of water, the gas being injected into the feed line, and with the small ratio of gas required the CO_2 is completely absorbed by the water so that a representative sample is readily obtained. The gas is then completely separated from the water and the ratio determined by the measurement of each.

It will be noted that this method is entirely independent of steam pressure, superheat or percentage of moisture, and it resolves back to an actual weight basis. It requires no change in piping except to drill and tap for ⅛-in. pipe at two places. It is particularly adapted for test work in calibrating meters, determining steam consumption of turbines, engines, pumps, auxiliaries, etc., but does not take the place of a permanently installed recording or integrating meter.

DISCUSSION

In the discussion which followed the paper, Walter S. Burke, Mem.Am.Soc.M.E., Superintendent of Buildings and Grounds at Harvard University, described the meters used by the University to measure steam flow and condensation in the purchase of steam from the Boston Elevated Company, amounting to some $40,000 per year. The net B.t.u. are computed and paid for on the basis of heat supply.

Mr. Burke considered the CO_2 method of calibrating steam meters very valuable, affording a convenient and close method of determining just what results the meter is giving. He regarded Mr. Bailey's method of showing steam flow, air flow and condition of fuel bed on one chart for use of the firemen in handling the fire very important. In his experience with the Bailey meter, results within a small fraction of 1 per cent had been effected by using steam meters to show the requirements of the various departments.

A. G. DUNCAN, Mem.Am.Soc.M.E., stated that in the mills with which he was connected he believed a saving of 25 per cent has been effected by using steam meters to show the requirements of the various departments.

EDWARD A. UEHLING, Mem.Am.Soc.M.E., considered the Bailey meter would serve a useful purpose, and, inasmuch as the majority of practical engineers prefer physical and mechanical means to chemical means for the control of combustion, no doubt many would prefer his apparatus to the CO_2 recorder.

JOHN A. STEVENS, Mem.Am.Soc.M.E., gave his experiences in regard to measuring steam from several sources with a single meter, with suitable valves to cut off the sources as required.

HEAVY-OIL ENGINES

A Discussion of the Question of Availability of Fuel, Followed by Some Observations on Oil Engines in General and the Diesel Type in Particular

By S. B. DAUGHERTY, BUFFALO, N. Y.

Member of the Society

IN a consideration of the oil engine, the questions at once arise: What kind of oil is suitable? Are supplies of fuel available in sufficient quantities in various parts of the country? Will the probable production of oil in years to come be equal to the demand?

To answer the first question requires a word of explanation as to the types of oil engines. Broadly there are two: the low-compression engine, wherein ignition is effected by the injection of the oil spray against a heated surface, or even by an electric igniter, as in gas engines; and the high-compression, or Diesel type, with ignition from the heat of compression of the air charge. The low-compression engines are the simpler and cheaper, but on the other hand suitable fuels for use in them are fewer and higher-priced, and the thermal efficiency is less. These limitations tend to restrict the use of low-compression engines to smaller installations. Suitable oils are kerosene, the lighter distillates and light crude oils.

The high-compression or Diesel-type engines can in general utilize any liquid fuel. It is to be remembered that there is no strict line of demarcation between the types, but that they tend to merge one into the other. The grades of suitable oils vary inversely as the grade of the engine,—the cheaper and simpler the engine, the higher the grade of oil required; the more elaborate and specialized the engine, the lower the grade of oil which may be successfully used.

AVAILABILITY OF FUEL IN THE UNITED STATES

The date of the beginning of the production of petroleum or mineral oil in this country is recorded in government publications as 1859, the production of that year being 2,000 bbl. of 42 gal. each. The United States production marketed in 1914, the last year for which statistics are available, was 265,762,535 barrels.

There are six major oil fields of the United States: the Appalachian, the Lima Indiana, the Mid-Continent, the Illinois, the Gulf and the California.

The quality of the oil produced in the Appalachian field is the best. It is light, yielding a large percentage of gasoline and kerosene, and paraffin is obtained from the residuum; the Lima Indiana oil is also light, but contains sulphur; the Illinois oil contains less sulphur than Lima Indiana oil, but contains some asphalt as well as paraffin; oils of the Mid-Continent field contain paraffin and asphalt and show considerable variation; those from the Gulf field contain considerable sulphur, while the California oils in general contain much asphalt and considerable sulphur. Some of the California oils are valueless to the refiner and find their market as fuel oil or as road oil.

In addition to the oil produced in the United States, there is an enormous potential production in Mexico. This oil is asphaltic and contains often as much as 3½ per cent sulphur. It finds a ready market as fuel oil and can be sold in the ports of New England at a price that allows of its being used as fuel under boilers in competition with coal. In Florida, Mexican crude is used extensively.

A general survey of the statistics shows that the total production of oil in the United States is increasing. This increase is in the lower-grade oils, as the production of the Appalachian field is decreasing, even though the price has recently been maintained at a fairly high level.

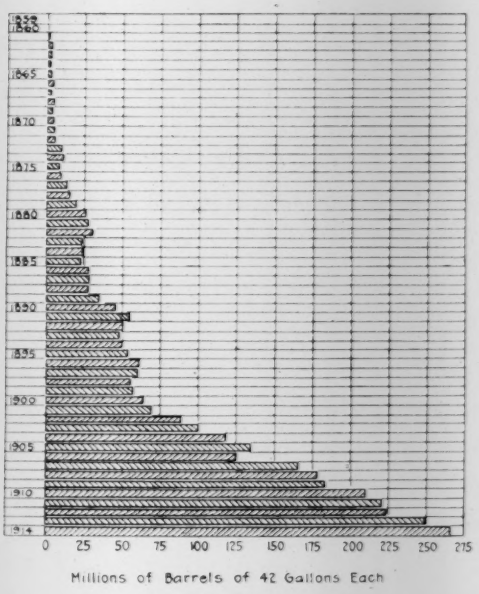

FIG. 1 ANNUAL PRODUCTION OF PETROLEUM IN THE UNITED STATES

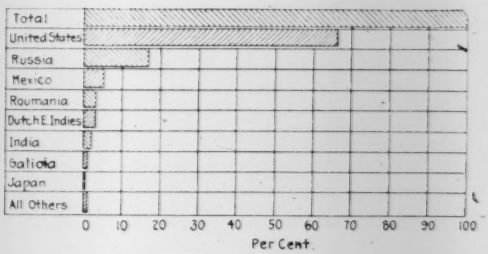

FIG. 2 WORLD'S PRODUCTION OF PETROLEUM IN 1914

New fields are being discovered and the limits of old fields are being extended. It is probable that for many years the total production will increase. In fact, it is the opinion of experts that the petroleum resources of the world are relatively undeveloped. Some fields are enormously productive, as for instance the Cushing pool, which a year ago was producing at the rate of about 30,000 bbl. per day; the production of this field has decreased so that now it is about 12,000 bbl. daily.

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Consumption of petroleum products is constantly on the increase. This applies particularly to gasoline. It is estimated that the automobiles of this country are consuming over 1,000,000,000 gal. annually. In addition to this amount the yearly consumption of gasoline for other purposes is about 500,000,000 gallons.

It is in this enormous demand for gasoline that there is an assurance of a reasonable supply of oil suitable for use in engines. Part of this supply is the residue from refining operations, and a great portion is in the lower grades of crude oil discovered in the search for new supplies. Fig. 1 shows the annual production of petroleum in the United States from 1859 to 1914. Fig. 2 shows the total production of the world for 1914, and the percentages produced in the different countries.

A first impression would be that any decided increase in the number of oil engines in use would create such a demand for fuel oil that prices would advance to a figure which would make the oil engine unprofitable. But this does not take into consideration the fact that in many cases the oil engine supplants an oil-fired boiler, and that but 1/5 to 1/10 of the oil burned under the boiler is required for the oil engine, the remainder being available for other purposes. It must also be remembered that the price of fuel oils is largely determined by the price of other fuels. Heat units in oil must not be much higher priced than heat units in other fuels, or there is no market for the oil. For many years the price of low-grade oils will be determined by the demand for other purposes than use in oil engines.

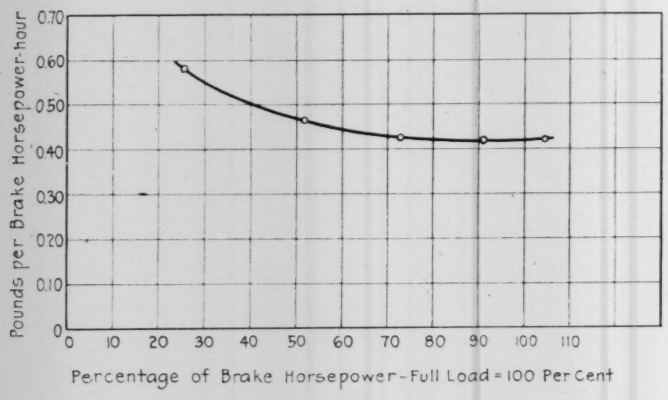

FIG. 3 FUEL CONSUMPTION, 4-CYCLE "SNOW" OIL ENGINE, FROM ACTUAL BRAKE TESTS

OIL ENGINES, DIESEL AND SEMI-DIESEL

This paper will consider Diesel-type engines particularly. The Diesel engine is the most economical prime mover yet designed. It is now twenty-two years since the engine was patented in Germany. The engine was developed by the Augsburg-Nürnberg Co. The first commercial engine was put in service in 1897, and, according to the Augsburg-Nürnberg Company, was still in service and running satisfactorily in 1911.

The Diesel engine is unique, in that it was designed to fit a theory. Some of the paragraphs in Diesel's patent show clearly that his calculations were not entirely correct; for instance, his statement that there is "no increase in the temperature produced on the introduction of the fuel, or at most only a very slight one, and the highest or extreme temperature is produced by the compression of the air. It is, therefore, under control and will be kept within moderate limits, and moreover, in view of the cooling of the products of combustion by the subsequent expansion, no artificial cooling is required for the cylinder, the mean temperature of the gases being such that the parts of the engine can be kept tight and lubricated;" also that "the exhaust may be cooled by expansion below the temperature of the atmosphere and utilized for refrigerating purposes." Experiment has proven these statements incorrect, but in its essential features his theory was sound. The first claim in his patent covers the engine so completely that, so far as I am aware, no infringement was ever attempted. This is the claim: *"The herein-described process of converting the heat energy of fuel into work, consisting of first compressing air, or a mixture of air and neutral gas or vapor, to a degree producing a temperature above the igniting point of the fuel to be consumed, then gradually introducing the fuel for combustion into the compressed air, expanding against a resistance sufficiently to prevent an essential increase of temperature and pressure, then discontinuing the supply of fuel and further expanding without transfer of heat."*

The first Diesel engine was a vertical machine, and this design was followed in subsequent engines until it became so standardized in Europe that the opinion prevails to a great extent that there must be some vital reason for the adoption of the vertical type. The first commercial engine was a twin-cylinder vertical engine of 60 b.h.p. Both horizontal and vertical Diesel engines are now being built in the United States, and the expiration of Diesel's patent in July, 1912, was the occasion of many builders entering the field.

In addition to Diesel engines, the De La Vergne type FH engine should be mentioned. It is classed as semi-Diesel but its equipment includes all of the essentials of a Diesel engine, and the compression needs only to be raised from about 350 to 500 lb. in order to bring it into the Diesel class. The economy of this engine is practically the same as that of the true Diesel type.

ECONOMY OF THE DIESEL ENGINE

As stated, the main feature of the Diesel engine is its economy. The measure of efficiency of a prime mover is the percentage of potential power actually obtained for useful work. In the transformation of heat energy into useful power various losses occur. If steam be the medium, there will be a loss of heat in the boiler, due to radiation, to the escape of heat into the stack with the gases formed by combustion of the fuel, and to imperfect combustion of the fuel. Heat in the steam is lost by radiation, and a very considerable amount is rejected in the exhaust. Friction accounts for a further loss, and so, with steam as a prime mover, the percentage of actual heat in the fuel that is transformed into work ranges from 6 per cent to 16 per cent. For intermittent operation, where a considerable portion of the fuel burned is for stand-by service, the percentage may be even lower. In the internal-combustion engine the heat losses are due to radiation, to heat carried off in the jacket water and in the exhaust, and to friction. The principal saving is in the reduction of the amount of heat lost in the exhaust.

The effective thermal efficiencies of various prime movers are about as follows:

Non-condensing steam engine	8.4 to 6.6 per cent
Condensing steam engine and turbine using superheated steam	15 to 10 " "
Suction gas engine	23 to 18 " "
Four-cycle Diesel engine	34 to 32 " "

The significance of this Diesel-engine economy can best be appreciated by a familiar comparison: Assume that a touring car can be run twelve miles on a gallon of gasoline which costs 23 cents per gallon and weighs about 6 lb. Assume that the engine has a thermal efficiency of 18 per cent, and that the effective heating value of the gasoline is 114,000 B.t.u. per gallon.

Fuel oil weighing about 7.5 lb. per gallon would have an effective heating value of about 135,000 B.t.u. per gallon. On this basis of relative heat values and efficiencies a Diesel-type engine would drive a car 26 miles on a gallon of oil, as compared with 12 miles with gasoline. But 7.66 gal. of oil can be purchased for the price of one gallon of gasoline, so that the distance covered for 23 cents worth of fuel would be 200 miles with oil and 12 miles with gasoline, or 16.6 times.

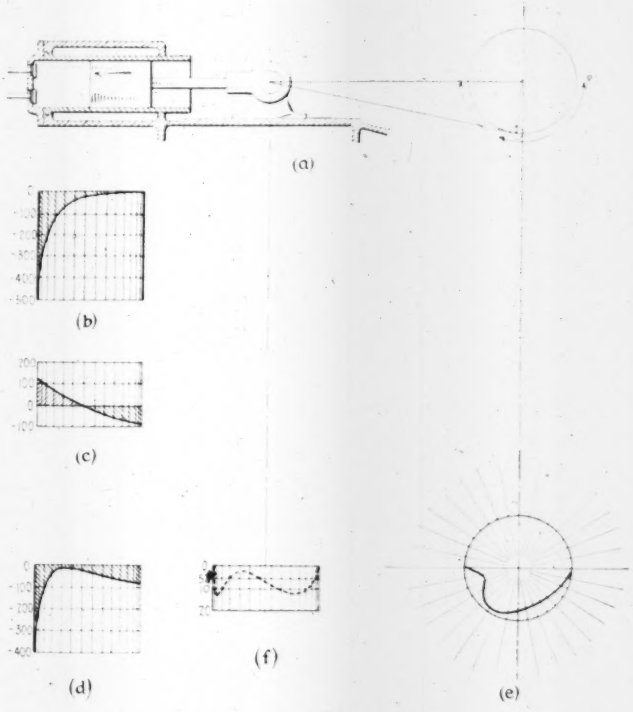

FIG. 4 PISTON-EFFORT DIAGRAMS FOR HORIZONTAL OIL ENGINE, COMPRESSION STROKE

VERTICAL VS. HORIZONTAL DIESEL ENGINES

One of the outstanding features of Diesel-engine manufacture in the United States is that, in general, those manufacturers who have done their own designing have brought out horizontal engines, while those who are building vertical engines have purchased the designs abroad.

The advantages of the horizontal engine, as enumerated by a concern with an established reputation as builders of vertical engines are: lower price; easy survey and convenient attendance; better distribution of stresses on the crankshaft and main bearings; better lubrication of bearings; better lubrication of piston; easier cleaning and repair work, especially to pistons, which can be taken out without removing the cylinder head and the valve gear; reduced height of engine room, as

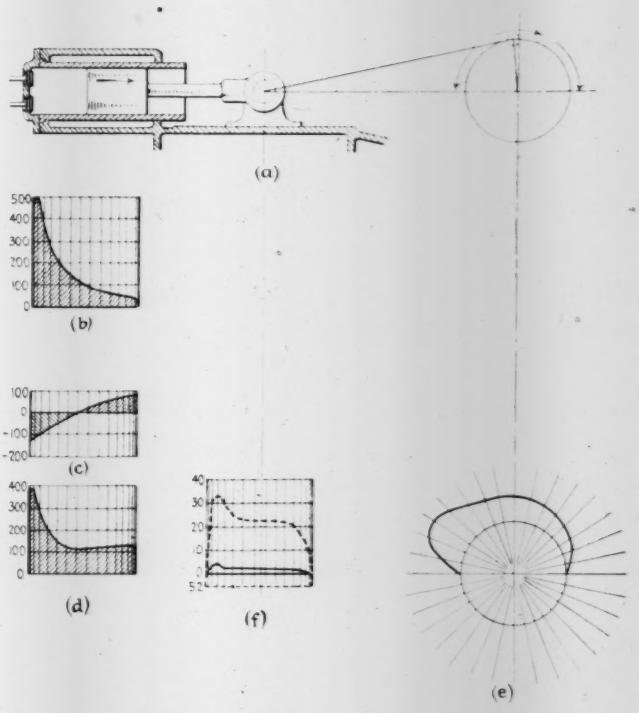

FIG. 5 PISTON-EFFORT DIAGRAMS FOR HORIZONTAL OIL ENGINE, WORKING STROKE

(*a*), frame diagram; (*b*), compression diagram; (*c*), inertia diagram; (*d*), combined compression and inertia; (*e*), crank effort; (*f*), reaction on crosshead guide

Fig. 3 shows the fuel-consumption curve of a single-cylinder four-cycle engine. At loads from 80 per cent to full load the consumption is practically constant, and at the rate of 0.42 lb. per b.h.p-hr. At this rate one gallon of oil will furnish about 18 b.h.p-hr., and the cost for fuel per b.h.p-hr. with oil at 3 cents per gal. is one and two-thirds mills. To supply 100 h.p. for ten hours would require 55½ gal. of oil, costing $1.67.

The opponents of internal-combustion engines, both gas and oil, always state that these engines are economical only when operating near maximum load, and that the economy falls off rapidly as the loads decrease. Observe on this curve that the load is approximately 42 per cent where the consumption curve crosses the 0.5 lb. line, and that the consumption at half load is 0.47 lb. The fuel consumption for a ten-hour day, running a 100-h.p. engine at half load, would be about 31½ gal., costing, at 3 cents per gal., 95 cents. It is evident that the fuel expense for keeping an engine running on friction load is very slight. By actual test on a 65-h.p. engine, full speed without load was maintained on 1.1 gal. per hour.

all pipes are laid in trenches under the floor and do not obstruct the room.

In a comparison of vertical and horizontal Diesel engines the detail most discussed is the piston. Vertical builders call attention to the weight of the piston, and the side pressure thereby produced on the cylinder bore, in the case of the horizontal engine. The fact that the first Diesel engines were built vertical, and that excessive height was undesirable, probably led to the use of trunk pistons. For the same reason a connecting rod of a length but slightly more than five cranks has been used in vertical engines. An analysis of the forces prevailing throughout the cycle of operations shows that the side pressure on the cylinder walls, due to the angularity of the connecting rod, is far greater than the pressure due to the weight of a piston, even though the piston lies horizontally. Any increase in connecting-rod length means a proportional decrease in the side thrust. Ordinarily an increase in the length of the connecting rod of one crank length decreases the side thrust an amount equal to the weight of a piston and

wrist pin, or, in other words, a vertical trunk-piston engine with a connecting rod five cranks long is subjected to about the same side pressure on the cylinder wall as a horizontal trunk-piston engine with a connecting rod six cranks long.

The magnitude of the forces involved in the engine is not generally realized. Weight is obvious, but loads due to fluid pressure inside of cylinders and the reactions resulting therefrom are not so readily appreciated. For example, with a connecting rod five cranks long, and the engine crank 45 deg. from dead center on the working stroke, the side thrust on the piston, not considering the modifying effect of inertia of the reciprocating parts, is about 41 lb. per sq. in. of piston area. For a 19-in. diameter piston, this is $284 \times 41 = 11640$ lb. The weight of a 19-in. piston with wrist pin and one-half of the connecting rod is approximately 1600 lb. The side thrust due to angularity of the connecting rod for this condition is about 7.3 times the weight of piston. In actual running, the force transmitted to the crank pin through the connecting rod is reduced by inertia effects, so that the side thrust due to angularity is from five to six times the piston weight instead of 7.3 times.

In order to present this feature more clearly, diagrams are given showing the pressures acting on the piston during the compression and working strokes; the inertia; the combined inertia and pressures, which is the measure of the effort transmitted to the crank pin; the turning effort on the crank pin, and the resulting thrusts due to the angularity of the connecting rod. The figures on the diagrams are in pounds per square inch of piston area.

In these piston-effort diagrams, the forces which tend to drive the crank in clockwise direction are shown above the horizontal base line, and those forces that would tend to drive the crank in the reverse direction are shown below the base line.

Beginning with the compression stroke, Fig. 4*a*, note that the crank is driving the piston against a constantly increasing pressure, which reaches 500 lb. per sq. in. at the end of the compression stroke, Fig. 4*b*. At the beginning of the compression stroke, when the inertia of the reciprocating weights must be overcome, the pressure in the cylinder is low. At the end of the compression stroke the inertia effect is tending to revolve the crank in clockwise direction, as shown in Fig. 4*c*. Note, in Fig. 4*d*, how closely the line approaches the base. An increase in the weight of the reciprocating parts or an increase in the rotative speed of the engine would cause the line to cross the base line, or, in other words, would result in the piston actually pulling the crank during a short portion of the compression stroke; such a condition tends to cause a knock. From this piston-effort curve the negative turning effort on the crank is obtained, Fig. 4*e*, and the reaction on the crosshead due to the angularity of the connecting rod, Fig. 4*f*. On the compression stroke, the tendency is to lift the crosshead throughout the stroke. The upward thrust is maximum near the end of the compression stroke, and equals 14.5 lb. per sq. in. of piston area. The weight is about 5.2 lb. per sq. in., so that the net upward thrust is 9.3 lb. per sq. in. of piston area, or about 2610 lb. for a 19-in. piston. This upward thrust is resisted by adjustable gibs bearing on the sides of the crosshead shoe, and no trouble is experienced in making these adjustments so that the engine runs quietly.

At the end of the compression stroke, fuel is injected and the working stroke follows, Fig. 5*a*. The pressures in the cylinder through out the stroke are indicated in Fig. 5*b*. The inertia diagram for this stroke is shown in Fig. 5*c*. Note particularly, in Figs. 4*d* and 5*d*, the beneficial effect of inertia in reducing the high pressures at the end of the compression stroke and the beginning of the working stroke, and in supplementing the low pressures in the cylinder at the end of the working stroke so that the effort is more evenly distributed. During this stroke the thrust due to the angularity of the connecting rod is all downward, Fig. 5*f*, and reaches a maximum of 32.6 lb. per sq. in. of piston area. Adding the weight to this, the maximum downward pressure is 37.8 lb. per sq. in. of piston area, or 10,700 lb. For a 19-in. diam. piston, note particularly that if the cylinder were vertical there would still be a maximum side thrust of 9250 lb.

From the foregoing it will be very apparent that it makes but little difference whether an engine is built vertical or horizontal in so far as side pressures are concerned. In the case above analyzed, weight adds but 16 per cent if the maximum pressure is considered. The advantage of the horizontal engine in general, and the crosshead type in particular, is in its superior accessibility. In the case of a vertical trunk-piston engine it is necessary to practically dismantle the engine in order to get at the piston, piston rings, or wrist-pin bearings. In most cases the valve gear and the cylinder heads must be removed, the connecting rod must be disconnected at the crank pin, and the piston and piston rod then lifted out through the cylinder.

Compare this procedure with that necessary in the horizontal engine: The sheet-steel crank splasher is removed; then the connecting rod is disconnected, at the crank pin in the case of a trunk-piston type, or more simply at the wrist pin if the engine has a crosshead, and the piston is then removed from the open end of the cylinder. The actual time required to remove a piston and cross head of a 19-in. by 33-in. engine was twenty minutes. The piston was wiped clean and replaced in thirty minutes, making the total shut-down fifty minutes, as compared with about one day of ten hours to accomplish the same thing in the case of a vertical engine.

TYPE OF DIESEL ENGINE AND LUBRICATION

The matter of cylinder lubrication is another feature of superiority in horizontal engines. In the vertical type it is absolutely essential, in order to secure a distribution of the lubricant around the cylinder bore, to supply the oil through a number of feeds, as many as four per cylinder on the smallest sizes and more on larger diameters. A horizontal cylinder, on the other hand, even of the largest size that is practicable to build, can be effectively lubricated over its whole surface from a single feed on the upper side. Gravity helps to distribute the oil.

In any internal-combustion engine some of the lubricating oil is carbonized. In a vertical engine this carbon tends to work down past the piston, fouling the rings and dropping into the crank pit, where it becomes mixed with the bearing oil. In the horizontal type, much of this carbon is pushed into the counterbore, whence it can be removed through a blow-off valve in the bottom of the cylinder. Such portion as works by the piston can be caught in the frame and prevented from mixing with the bearing lubricating oil. Even the main bearings in a horizontal engine are more effectually lubricated. During the working stroke, when the pressures are highest, the main shaft is partly lifted from the bottom shell, allowing the lubricant to fill the space. Then on the two idle strokes, the exhaust and inlet, inertia effects tend to bring the shaft first against one side of the bearing, then against the other, thus effecting a very thorough distribution of the oil.

SUCCESS IN DIESEL-ENGINE OPERATION

On the showing of economy of the Diesel engine, one might ask why the engines are not in more general use, since the United States is the great producer of oil and power is so universally used. One answer is that those who are in a position to reap the most benefit are not aware of the possibilities. Perhaps they have heard of an oil-engine installation that has not come up to expectations. Without investigation, they immediately condemn oil engines in general. Or it may be that even when an engine of a suitable type has been installed, satisfactory operation is not obtained on account of the failure of the men in charge to properly care for the engine.

It is evident that in a machine that requires uniformly high pressure to properly ignite the fuel charge, any appreciable leakage of valves or piston rings results in faulty ignition. This applies to the compressor which furnishes the spraying air as well as to the power cylinder. On the other hand, a little intelligent care will prevent trouble of this kind. I know of no case where the proverb, "a stitch in time saves nine," is more applicable.

Another cause of trouble that is avoidable is overloading. A moment's consideration will make plain the ill effects of overloading. In any internal-combustion engine the amount of fuel burned is limited by the oxygen in the charge of air at the end of the compression stroke. In the case of a Diesel-type engine the time available for burning the fuel charge at full load will not exceed 35 deg. of crank travel. In the case of an engine running 200 r.p.m. this is equivalent to $^1/_{34}$ of a second. During this time the oil must enter the cylinder, come in contact with the necessary oxygen, and be consumed. There must of necessity be some excess oxygen in order to effect complete combustion of the fuel. The effect of overloading is to increase the fuel charge so that the amount is greater than can be burned clean with the air that is available. The result is that combustion continues after expansion has begun, and if the overload is great it may even be that the charge will be still burning when the exhaust valve is opened. The temperature of the exhaust gases is then so far above normal that the valve becomes distorted with the heat, causing leaks which still further aggravate the trouble. If an engine be allowed to run with a leaking valve it is only a question of a few hours until both valve and seat will be cut out by hot gases blowing through at high velocities. The secret of success in operating a Diesel engine is in taking care of just such relatively small items. When you find an owner who condemns this type of engine, you will generally find that he is careless, and allows his engine to get out of order in some small particular, and then complains about unreliability, high cost of repairs, etc.

FIELD OF THE DIESEL ENGINE

The Diesel engine has a fairly well defined field in which it will have no competitor when its merits are known and appreciated. This is the relatively small plant which, when steam operated, is usually inefficient. In generating electric current for a small town, savings are effected that would justify the installation of the Diesel engine if the cost were two or three times what it actually is. For instance, a 300-h.p. engine is effecting a saving of $1000.00 per month in fuel. In another case a 60-h.p. is saving $2500.00 a year. In ice making the cost of fuel per ton of ice with oil at 3 cents per gal. is around 18 to 20 cents per ton of ice produced. This includes driving all the auxiliaries, lighting the plant, etc. For pumping, the combination of an oil engine with a geared power pump makes a pumping unit that has a higher thermal efficiency than the best crank-and-flywheel pumping engine ever built, and this efficiency can be obtained when the oil engine is only 65 h.p., compared with hundreds of horsepower in the steam-driven pump. This means that in parts of the country where oil is used under boilers, oil-engine-driven pumps in small units are pumping water cheaper than is done by the largest steam-driven pumps. Of course, where heat units in coal can be purchased cheaper than heat units in oil, this advantage of the higher efficiency of the oil engine is offset, but it is probable that there is no place in the United States where the power requirements for pumping are around 50 to 60 h.p. that an oil-engine-driven pump would not be the most economical, all things considered.

The ability to generate electric power cheaply by means of Diesel engines has led to the installation of engines of this type in the phosphate-mining industry in Florida. The load conditions are almost ideal for the realization of high economy. The plants are operated continuously except for a Sunday shutdown. It has been found that multi-stage centrifugal pumps motor-driven will deliver water at the high pressure required for hydraulic mining at an expense that compares most favorably with compound-condensing pumping engines. The advantage of this combination lies in the ability to shift the pump and motor with but little trouble as the mining progresses, thereby saving the expense and losses due to extending pipe lines from a permanently located pumping unit.

The pipe-line companies have come to appreciate the merits of the oil engine for driving pumps. A large number of units have been installed, mostly of relatively small sizes, the 100-h.p. De La Vergne engine having been very popular. But now that horizontal Diesel type engines are to be had, larger units are being used. The economies effected are such that it is only a question of time when steam engines for this service will be abandoned.

DISCUSSION

The discussion of the paper was active and interesting. The principal points discussed were the opportunities for the Diesel type of oil engine and the matter of lubrication. It was believed that the Diesel engine would find more extensive use as it became better known. Its possibilities are not fully appreciated at the present time and it offers a great field for economical power units. If more scientific consideration be given the lubrication of the oil-engine units it was believed that more economical operation and better service would result. Several instances of exceptional oil-engine performances were mentioned. In one case an oil engine operating a refrigerating plant in the South ran for over 11 months without a shutdown. The experience of those using oil, having an asphaltum base, showed that the difficulties expected were greatly overestimated and that it could be used very satisfactorily. Among those discussing the paper were A. W. Moseley, Mem.Am.Soc.M.E., H. S. Philbrick, Mem.Am.Soc.M.E., O. J. May, Mem.Am.Soc.M.E., L. F. Burger, O. B. Zimmerman, Mem.Am.Soc.M.E., W. A. Hartley, Mem.Am.Soc.M.E., and F. G. Hobart, Mem.Am.Soc.M.E.

The exchange of heat between superheated steam and pipe walls or condensers has been investigated by R. Poensgen (*Zeit. Ver. deutsch. Ing.*, Jan. 8 and 15, 1916). His experiments were carried out with a seamless tube 3.5 m. long and 95.7 and 39.4 mm. in internal diameter in a gas-fired superheater, an auxiliary electric superheater being also provided.

MOTOR TRUCKS IN SOUTHERN CALIFORNIA

Notes on the Development of the Motor Truck, the Economics of Truck Operation, in Southern California, and Costs in the Southwest

BY W. HOWARD CLAPP, PASADENA, CAL.

Member of the Society

Motor-truck service on American roads is the severest kind of service, and in discussing the economic possibilities of motor trucks many factors must be taken into account.

This paper first reviews the development of American motor trucks, describing types of chassis, engine, transmission system, final drive, and other elements.

It then discusses the economics of truck operation and costs of gasoline trucks in Southern California—an ideal field for motor-truck service on account of perfect operating conditions throughout the year.

The author concludes with a discussion of the methods of reducing trucking costs and a comparison of operating costs of horse-drawn and motor trucks for general application.

THE object of this paper is to outline the development of the motor truck and to tell something of its economic possibilities under the conditions in Southern California. No attempt will be made to go into the many differences in the details of design for the great variety of trucks. The broader differences in construction will be brought out and the advantages or objections which they embody will be mentioned.

Commercial motor vehicles were at first simple pleasure cars with improvised truck bodies. The first ones were steam- or electric-driven, but were not successful, chiefly because of the inadequate capacity of the boilers and batteries. The steam-driven truck or lorry was developed successfully in England, but on the poorer roads of this country it was a failure. On the other hand, the electric truck has been continually improved from the first, and has reached its highest development here in this country.

The first recorded sale of a truck was in 1896, and in 1904 a truck made an endurance run from New York to Chicago which attracted wide attention. The manufacture of trucks was at first only a side-issue with pleasure-car makers, and there were few users prior to 1910; since then the sale of trucks in the United States has just about equaled the sale of pleasure cars for the period six to seven years before. Last year's sales totaled 72,000, an increase of 43 per cent over the previous year. Europe took about 22,000 trucks, but sales in this country increased also.

MOTOR-TRUCK CHASSIS

The design of the truck at first was patterned very closely after the pleasure car. This was a natural sequence for a business growing up as a branch of pleasure-car manufacturing. The same type of engine was used for both and the same drive through a differential on a live rear axle, such as still in use for trucks of the light delivery type. For the heavier trucks the frame of the car was lengthened out, and the differential and rear axle gave way to a differential and jackshaft attached to the frame. The jackshaft carried sprockets, and the final drive was made by chain to the rear wheels, which were carried on a dead axle. This arrangement had three obvious advantages: first, it kept the engine drive as small and light as possible, since the final reduction in rotations was made right at the rear wheels; second, it was accessible, and the gear ratio could be changed at will by putting a different-size sprocket on the jackshaft; lastly, it segregated the power plant so that the truck from the design viewpoint might be considered as made up of two separate units. The first of these units, the wheels, axles and steering gear, was expected to take all of the jar and distortion of running, while the other unit, the truck frame and power plant, floated above the first one on the springs, the chain furnishing the power connection between the two units. Automobile engineers state that each pound of unsprung weight is as hard on the tires, and therefore on the truck, as four pounds would be if placed above the springs, where the effects of the weight are cushioned. The chain drive kept the weight of the parts a minimum, and also kept it above the springs.

It was soon discovered that it was not possible to absorb all of the vibration and twisting which hard service gives to a truck without transmitting a considerable part of it to the frame and power plant. To the jar from the road was also added the twistings set up in the frame because of eccentric loading, and these effects were all transmitted to the power plant, to the radiator and to all parts which were attached rigidly to the frame. There were two possible ways of dealing with this difficulty: first, a more rigid frame and a better cushioning through the tires and springs; or, second, a flexible frame to which the various power-plant units would be flexibly mounted, so that each unit, while in itself a compact, rigid, perfectly aligned machine, would not suffer distortion by twisting set up in the frame. These units would be connected by shafts having universal joints or some other flexible connection. The modern truck has been developed along both of these lines. For the lighter and faster-running delivery truck the pneumatic tire is largely used, and its use is being extended to heavier trucks. Double pneumatic tires for the rear wheels are being used somewhat, and single pneumatics are being made up to 12 in. tread diameter. Both pneumatic and solid tires have been made as elastic as possible without sacrificing too much the other desirable qualities. Truck springs have been greatly improved also. The older types of truck springs were made up of rather thick leaves. They were short and narrow and had considerable camber. With the ad-

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vent of modern heat-treated steel there has been developed a much better design of spring, with thinner leaves, and which is longer and flatter and much better suited to the needs of the truck. They are made of high-grade carbon or alloy steel, with the leaves self-lubricated and the spring eyes provided with phosphor-bronze bushings. The pins are nickel steel and the clips of chrome-nickel or vanadium steel. The old-fashioned full elliptical type has given place to the semi-elliptical as the preferred type. This improvement in the design and quality of springs and tires has gone far to reduce the strains set up in the frame.

But truck service on American roads is the severest sort of service: the uneven roads, which alternately elevate or depress diagonally opposite wheels; the chuckholes, into which a driver will plunge the truck at full speed; and the load on the vehicle, which is frequently thrown on without any regard to the way it strains the frame—all these tend to twist the frame members, and through them the power-plant units themselves. It is not possible to absorb all of these jars and distortions below the frame members as is done in the lighter and more resilient pleasure car. The method of mounting the power-plant units in gasoline trucks so that they shall not be distorted and jarred is a very important part of truck design. In the smaller trucks, up to about two tons capacity, it is possible to combine the engine, the flywheel and its clutch, and the transmission all in one rigid assembly. This gives perfect alignment. This unit power plant is then flexibly mounted within the main frame, usually with three points of support, two rigidly attached to the main frame and the third swiveled from a bearing on a main-frame cross-member. Another method is to mount the power plant rigidly to a sub-frame, which, in turn, is flexibly mounted within the main frame. This mounting may be a three-point support or one of four points, with spring buffers to absorb the jar and twist. Where the transmission is separate from the engine it is also flexibly mounted to the frame. The differential and jackshaft unit is treated the same way.

MOTOR-TRUCK ENGINES

Motor-truck engines do not differ greatly from those on pleasure cars. Motor-truck service is more severe and the engines are kept at capacity for longer times. For this reason the engines are run at slower speeds, from 800 to 1200 r.p.m. for trucks of one ton capacity or heavier, and the engines are therefore larger for the same horsepower. In general, truck engines are usually built stockier, with heavier crankshafts and connecting rods and larger bearings throughout. The water-jacket space is somewhat larger and the cylinder walls thicker, which permits more reboring. The radiator is larger than for the same size of pleasure-car engine. The valves, carburetor and intake manifold are often made smaller than on a pleasure car. This is possible with the slower speed, and has the advantage of preventing the driver from overspeeding the engine when it is not under governor control. Governors are now coming into general use, however, on trucks of one ton capacity or heavier. The governor throttles the gas mixture between the carburetor and the intake manifold. It may be driven from any exposed rotating part of the engine, or from the transmission, or from the wheel of the truck itself. The use of the governor does not prevent the driver from throwing out the clutch and racing the truck downhill. The four-cylinder, four-stroke-cycle engine is now standard for truck construction. There are a few makes of two-cylinder engines with the cylinders opposed to each other. One of this type has been very successful here in California. Also one or two builders have recently brought out six-cylinder engines, but their use for most work would not seem to be warranted at the present price of motor fuel. Four-cylinder construction is being used on more than 95 per cent of all trucks; and this condition will probably continue. The four-stroke cycle is made necessary by the varying load which every truck engine must handle.

Cylinders are cast separate, in pairs or *en bloc*. The preference seems to be for cylinders in pairs with either three or five crankshaft bearings for trucks of moderate to large size, and cylinders *en bloc* with three bearings for the smaller sizes. Individual cylinders are used on many of the larger trucks. As to the placing of valves in the cylinder, the same types obtain as on pleasure cars. There is a preference for the L-head type for the smaller engines up to about four inches in diameter, as ample valves may be used and still provide for the necessary water-cooling space around them. Nearly 80 per cent of all engines are of this type. With increase of cylinder diameter cooling is more difficult, and many makers prefer the T-head construction with valves on opposite sides of the cylinder. There are a few motors with the valves in the head, and some with one set of valves in the head and the other in the side. The advantages of these types, however, would be such as would recommend them for fast-running pleasure cars or racing automobiles rather than for motor-truck service. Owing to better design and balancing, the stroke on motor engines has been gradually increased, while the bore has been reduced. The bore-stroke ratio varies from 1 : 1.1 up to 1 : 1.5. Average sizes vary from $3\frac{1}{2}$ by $4\frac{3}{4}$ in. for a 1-ton truck up to 5 by 6 in. for a $7\frac{1}{2}$-ton machine.

The clutch is usually housed with the flywheel. The cone clutch with leather against metal and the cone a part of the flywheel itself has been the favorite until very recently. The more complex multiple-disk clutches with steel against steel or against bronze plates running in an oil bath, or steel against a built-up fabric of brass wire and asbestos running either in oil or running dry are also largely used. The dry type has been gaining in favor. In design it is accessible, frequently separately housed and removable from the engine train, and there is abundant surface to take care of the friction of starting.

TRANSMISSION SYSTEM

The transmission system on trucks was patterned after that on pleasure cars. There are a few friction-type or planetary-type transmissions on some of the lighter trucks, but the selective type with sliding gears, three speeds forward and a reverse, is the one which has been quite generally used. It has not been entirely successful for heavy truck duty. The operation of a transmission requires a certain amount of skill and respect for machinery not always found in an unskilled employee. There has been a marked tendency to adopt some form of individual clutch system for the heavier trucks. Also a fourth speed forward on these trucks is coming into use to meet the requirements of tractor duty and of starting under heavy load.

No matter what part of the truck is studied, one is impressed with the fact that for each part there are two or more radically different types of design competing for favor. Many of these parts have been brought out by manufacturers who make a specialty of one particular product. It is said

that 85 per cent of all trucks sold are almost entirely assembled products. Thus a manufacturer can assemble whatever parts he thinks are best suited to his particular truck. Whether some of these parts are better or not nearly so good and only cheaper is a thing which time alone will determine. For example, there are two methods of water cooling used on light truck engines, one the thermo syphon, for which the claim is made that it is simpler and just as effective, while opposed to the cheaper and simpler method is that of pump circulation, which tends to keep the engine cylinder more nearly uniform in temperature under all running conditions. Other examples of different design for truck parts are the frame members, which may be built-up shapes of channels or I's, very rigid and formerly exclusively used; or pressed-steel frames, which are lighter and more flexible, made of a higher grade of heat-treated steel, more expensive, but coming into increased favor with truck manufacturers. Again, the truck wheels may be of the wooden artillery type, of cast steel, or of built-up pressed-steel construction. For bearings flexible rollers and balls compete with the truncated cone roller. Brakes are either shoe or band, each of which may be either internally expanding or externally contracting. They may be placed both on the rear wheels, or one set, usually the service brakes, on the jackshaft on chain-drive machines or on the main shaft back of the transmission on the other types of drives. Again, there are four types of radiator construction, twenty standard types of carburetor, and nearly as many ignition systems. Lubrication may be by splash, by forced feed or a combination of both, and so with nearly every feature of truck construction.

But the development which is creating the widest interest and no end of argument among truck manufacturers is the final drive. For light-running trucks the pleasure-car type of drive with the differential on the rear axle is customary. Its use is restricted to cars of 1500 lb. capacity or less, as a greater gear reduction than about five to one gives such a big differential assembly that there is not enough road clearance. An additional speed reduction of some kind must be made for the heavier trucks. The many advantages of the chain drive have not been sufficient to overcome the objectionable features of exposed grit-collecting parts and broken chains. Three separate types have been developed to meet these objections. All are alike objectionable because they place an increased weight below the springs and because they are heavier than the chain-drive parts.

TYPES OF FINAL DRIVE

The first of these types, the double-reduction axle, uses one pair of bevel gears and one pair of spur gears trained together and housed with the differential on the rear axle. There is the advantage of enclosure of all working parts, quiet operation and no thrust loads on the differential. The assembly is heavy and there are a good many parts. Its use is now restricted to a few makes of light trucks of 1½ tons capacity or less. This drive has been very successful in standing up under long service.

The internal-gear drive is also a double-reduction drive, as two sets of gears are used. It is also like the chain drive, in that a dead axle carries the load while the differential is on a jackshaft, but in this drive the jackshaft is carried alongside of and parallel to the rear axle, while the chain connection gives way to a spur pinion running inside an annular gear on the rear wheel. It is quiet in operation and the parts are all enclosed. It has the advantage of a dead axle to carry the load, an argument that appeals to many customers; also the differential is smaller than that on the double-reduction drive, as it runs faster. There is, however, a thrust on the differential from the driving shaft. The weight-carrying axle is usually of I-beam construction, and the jackshaft may lie either in front of or back of this axle. This drive was first developed on the continent of Europe, and has been used increasingly in this country principally for trucks of from 1½ to 3 tons capacity.

The worm-gear drive, while it has met with much opposition, seems to be winning its way as the simplest and very possibly the most satisfactory of the three types. It has fewer parts, since the differential is carried within the worm wheel and the entire reduction is made in one step. There is a live rear axle which transmits the power to the rear wheels. This is usually of the full floating type, with the truck weight carried on the outside of the axle casing. The live axle must be of goodly size, as must also be the differential, since there is no reduction in rotations at the wheel. There is a heavy pressure between the worm and wheel, as the wheel is of small diameter. It is necessary to maintain the most exact alignment between the worm and wheel, which necessitates a very heavy built-up housing to carry the assembly. This housing is of cast construction, and all of this weight comes on the tires with no spring intervening. In spite of these objections, the worm drive, which was first successfully developed in England, has been increasing in favor very rapidly in this country, especially in the last year, and it is now being used on all sizes of trucks from ½ up to 6 tons capacity.

The success of the worm drive depends upon exact proportions, perfect alignment at all times, and, most important of all, the maintenance of an oil film which will not be squeezed out by the thrust of the worm shaft. It is now known that the efficiency of the worm depends entirely upon the condition of the oil film, and that this efficiency will remain practically constant under all conditions of running so long as the oil film is intact. Under test the pressures have been increased to a force per unit area comparable with the elastic limit of the bronze of the wheel, and the oil film has still held. This pressure is many times higher than is considered possible for any other pair of sliding surfaces at high speed, yet the coefficient of friction is only 0.02. Some of the interesting results of these tests are that the efficiency varies widely for different lubricants; that in general mineral oils are inferior to vegetable and animal oils; and that the best film is maintained at a moderately high rate of speed and with the gear box not too full of lubricant.

The methods of drive outlined are not necessarily limited in their application to the rear wheels of the truck. There are a variety of four-wheel drives on the market in which various combinations of internal gears or live axles are used to propel the truck through all four wheels. As the front wheels must swivel, and in some cases the rear wheels also are used in steering, it is necessary to provide for this in the drive either by knuckle joints or through a bevel-gear train with one gear mounted on the swiveling axis. These trucks are much used where the road conditions are severe, as for ore-hauling work in mountainous country or out on the desert, and for army transport work.

What has been said of the methods of driving gasoline trucks applies also to battery-driven electric trucks. These trucks, because of their simplicity and durability, and because of a high starting torque compared with the gasoline truck, are much used for work within their special fields. For de-

livery service in congested districts and where the number of stops per mile is large, and for special service such as street-work hauling with heavy loads and many stops, drawing in conduit wires, raising telephone poles and wholesale delivery, they are especially suited. Their use within these fields would be increased if the first cost were not so high. It is considerably more for the lighter types of truck. Electric trucks are handicapped by a slower speed, about 60 per cent of that of a gasoline truck, and the mileage is limited to between 35 and 45 miles per day as compared with 75 miles or more for the latter. Also, the electric must be brought to some point where direct current is available for charging the batteries. This charging is usually done at night, though the batteries may be given a slight boost during the noon hour or other convenient interval. For work for which they are suited the electric trucks will usually show a lower daily cost than gasoline trucks, where the latter are held down to the same number of miles a day. It frequently happens that it is not possible to get a greater mileage with the gasoline truck because of frequent stops and congested streets. The electric truck, with fewer parts, and none of these reciprocating, gives a lower maintenance cost outside of batteries, and the depreciation has been less than on the older types of gasoline trucks. There are many examples of electric trucks which have been in service for ten years or more and are still giving good service.

There is another type of truck which combines both the gasoline-engine and the electric-motor drive. The engine runs at a constant speed at all times, and is direct-connected to a generator which drives motors placed within the four built-up steel wheels of the truck. Each motor is carried by a steering knuckle, and the armature has a pinion at one end which engages with a ring gear on one side of the wheel, while a pinion on the opposite end of the armature engages with another gear on the opposite face of the wheel. This arrangement, while undoubtedly less efficient than the direct-connected drive, has all of the simplicity of the electric truck, for it does away with all chains, sprockets, clutches, sliding gears and differential. The mileage is unlimited, and it promises to meet the requirements of heavy duty and long-drawn-out service.

For every truck it is necessary to provide some means of resisting the rear-axle torque, which reacts on the driving gear and axle casing. The reduction gear on the rear axle tends to rotate instead of turning the wheel, and carries the axle casing with it. This turning must be prevented by some member connecting the casing with the main frame of the truck. Again, the thrust of the wheels against the roadbed must be made to react on the frame of the truck instead of upon the axle bearings alone, for the frame is suspended on the springs above the axles. There are several ways of taking care of these two forces. The torque may be taken through the rear springs or through separate torque rods swiveled from the rear-axle housing to the frame. The thrust may be transmitted through the rear springs, or through radius rods, and these rods may take both thrust and torque, or there may be separate rods for each duty. Where the springs take the thrust they are shackled at the rear end only, and the front end is pin-connected direct to the frame. A combined torque and radius rod is frequently used for the internal-gear drive axle, and for many of the smaller worm-drive trucks. The larger worm-drive trucks use separate torque and thrust rods.

ECONOMICS OF TRUCK OPERATION

Many things contribute to make Southern California an ideal field for the motor truck: perfect operating conditions throughout the year, many miles of good roads—city streets out into the country, a population which has scattered out instead of congesting, cheaper fuel than can be had in any other truck country, and a labor market where intelligent, careful drivers may be had for a moderate wage. For many kinds of haulage, covering a wide range of operation, the motor truck is distinctly superior to any other method of transportation. Given an active service at full load, with a terminal not definitely fixed and a radius of operation up to thirty miles, it is an exceptional condition which will justify any other method of goods haulage.

Some of the especially active fields for the truck in Southern California are goods hauling to and from Los Angeles harbor, interurban delivery service, road building and wholesalers' delivery. There are, however, special considerations which may have considerable bearing upon the employment of a truck. A committee of the Boston Chamber of Commerce, in a detailed report on street traffic in Boston, covering eighteen months of study, reported that "development of motor trucks will tend to relieve congestion by moving all merchandise in larger units and more rapidly," and that "the average speed of motor vehicles in getting into and away

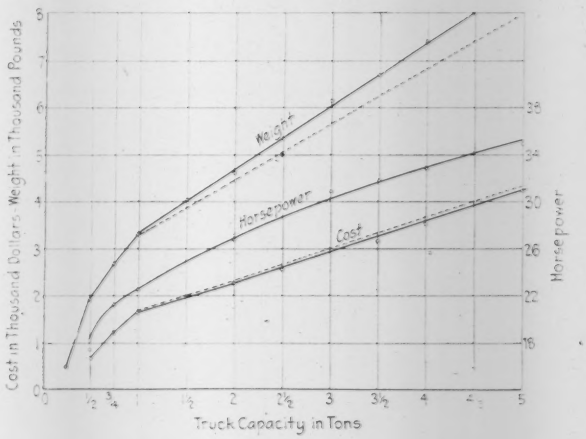

FIG. 1 AVERAGES FROM ALL CLASSES OF GASOLINE MOTOR TRUCKS

from railway terminals is from two to three times that of the horse." This is especially applicable to Los Angeles, which has nearly two miles of as congested streets as are to be found in nearly any city.

Another great advantage of the motor truck to the retailer is that he cannot only supply his customers more quickly, but also because of the greater mileage range his territory is increased to about eight times what he could serve with a horse.

COSTS OF GASOLINE TRUCKS

Fig. 1 gives curves of cost, weight and horsepower (average values) for all classes of gasoline trucks as listed by publishers of motor-truck publications. The noticeable feature of these curves is the sudden break of each for the lighter trucks of less than 1 ton capacity. These show that the demand for a light truck has been met by making a vehicle which is much lighter for the rated load than the heavier trucks. This is possible because of the higher engine speed, a more simple final drive, torque and thrust taken through the vehicle springs, and by the generous use of special alloys and heat-treated

steels. The curves suggest that these trucks are too light for the load that they are rated to carry. That this is true is abundantly proved by the records of many light trucks, which show that the average life of a light delivery truck is about 35,000 miles, whereas the heavier trucks when properly driven and cared for can be depended upon to give 80,000 to 100,000 miles, or even more for the better grade of trucks, if they are carefully driven and ordinary maintenance is kept up. It would seem that there is a real field for a more serviceable light truck which will at a little greater cost give enough lower depreciation and maintenance to be a profitable investment.

That there is a real field for such a truck not only for city service but also for use throughout the country is shown by the report of the U. S. Government, which states that only 15 per cent of the entire traffic of the country is moved by railroads and steamships combined, the remainder of 85 per cent being carried for the most part in wagons and the greater part of it in lots of 1000 lb. or less. This field has only been touched by the motor truck as yet, and to fully occupy it would require not less than two million light trucks. This estimate makes no provision for hauling done on the farm.

Table 1 is an itemized cost statement for various sizes of gasoline trucks under average service conditions on the roads of Southern California. These costs are conservative. It is possible to find plenty of examples of lower costs and also of costs that are much higher, but these costs are easily realizable for ordinary truck work in this locality. With proper management an even lower cost per day should be realized. That these costs are somewhat lower than averages for other localities may be largely credited to good roads and an equable climate. In making this table three conditions of operation are assumed: the costs for each size of truck are computed for a daily run of 25, 50 and 75 miles, and for each condition the life of the truck is estimated, and depreciation is based on this life. Costs are given in dollars for the entire life of the truck. First costs are average chassis costs in Los Angeles.

In California distillate is being used to quite an extent as a substitute for gasoline. The cost per gallon is about half that of gasoline at the present time, and the B.t.u. content somewhat greater. A local truck manufacturer has been very successful in equipping trucks with gasifiers by which the heat of the exhaust gases from the engine is used to heat the inlet air as it goes to the carburetor, and also to heat the mixture as it goes from the carburetor to the cylinder. A supply of gasoline is carried and used in starting. The consumption of distillate is about the same as that of gasoline. The success which has attended this innovation would seem to justify the claims of the manufacturer that the use of distillate does not increase carbon trouble. The question of a lessened volumetric efficiency is a negligible consideration.

Tires will outwear the manufacturers' guarantee at least twenty-five per cent when used on the good roads of Southern California. Smooth roads, dry surfaces and an equable climate all contribute to this result. Overloading and overspeeding are the things that shorten tire life. However, the important consideration is not tire economy, but economy of truck operation per ton of material carried; therefore, durability is only one factor that must be taken into account. Resilience, which prevents the wasting of truck power; cushion-

TABLE 1 TOTAL COST OF OPERATING GASOLINE MOTOR TRUCKS AT VARIOUS DAILY MILEAGES

Capacity of Truck	Cost in Dollars	Horsepower	Miles per Hour	Miles per Gallon of Gasoline	Daily Mileage	Estimated Life, Years	Total Mileage	Costs for Entire Life of Truck, in Dollars											Cost per Day, Dollars	Cost per Mile, Dollars	Cost per Ton-Mile, Dollars
								Insurance, Fire and Liability	License and Taxes	Interest at 6 per cent	Depreciation	Administration	Garaging	Gasoline at 16 Cents per Gal.	Oil, Grease and Waste	Tires (less first cost)	Driver's Salary	Inspection and Maintenance	Total			
Light delivery wagon	600	18	25	15	25	5	37,500	200	40	180	600	35	180	400	190	225	2,400	750	5,200	3.47	0.139	0.417
					50	2½	37,500	100	25	90	500	20	90	400	190	225	1,200	655	3,495	4.66	0.096	0.288
					75	1½	33,750	60	20	55	450	10	55	360	170	200	900	505	2,785	6.19	0.082	0.246
1500 lb.	1100	22	20	12	25	6	45,000	300	65	400	1100	110	215	600	340	270	3,600	1010	8,010	4.45	0.178	0.237
					50	3	45,000	150	50	230	950	55	110	600	340	270	1,800	900	5,455	6.06	0.121	0.161
					75	2	45,000	100	30	130	850	35	70	600	340	270	1,440	790	4,655	7.76	0.103	0.137
1 ton	1875	24	19	8	25	10	75,000	850	220	1125	1875	225	480	1500	560	1340	7,200	1900	17,275	5.76	0.230	0.230
					50	6½	97,500	550	140	730	1690	140	310	1950	730	1800	4,680	1900	14,620	7.50	0.150	0.150
					75	4	90,000	300	85	395	1500	90	170	1800	675	1640	3,468	1800	11,815	9.85	0.131	0.131
1½ tons	2150	25	18	7	25	10	75,000	1000	235	1290	2150	255	600	1710	560	1505	7,200	2000	18,505	6.17	0.247	0.165
					50	6½	97,500	650	150	840	1935	170	390	2230	730	2025	4,680	2000	15,800	8.10	0.162	0.109
					75	4	90,000	350	95	450	1725	100	210	2055	675	1850	3,360	1900	12,770	10.64	0.142	0.095
2 tons	2625	26	17	6	25	10	75,000	1150	265	1575	2625	315	720	2000	750	1840	7,200	2250	19,440	6.90	0.276	0.138
					50	6½	97,500	750	195	1025	2360	205	470	2600	975	2475	4,680	2250	17,985	9.22	0.184	0.092
					75	4	90,000	400	110	550	2100	125	250	2400	900	2255	3,360	2100	14,550	12.12	0.162	0.081
3½ tons	3500	32	14	5	25	10	75,000	1350	380	2100	3500	415	960	2400	750	2345	9,600	3250	25,700	9.02	0.361	0.103
					50	6½	97,500	875	215	1365	3150	270	625	3120	975	3150	6,240	3250	23,265	11.93	0.239	0.068
					75	4	90,000	460	150	735	2800	165	335	2880	900	2870	3,840	3000	18,135	15.11	0.201	0.057
5 tons	4600	35	12	3½	25	10	75,000	1760	440	2760	4600	550	1200	3430	750	2680	10,800	4000	32,970	10.99	0.439	0.088
					50	6½	97,500	1145	285	1845	4140	360	780	4460	975	3600	7,020	4000	28,610	14.67	0.297	0.059
					75	4	90,000	600	180	965	3680	220	480	4115	900	3280	4,320	3600	22,340	18.62	0.223	0.044
6½ tons	5000	40	10	3	25	10	75,000	1875	525	3000	5000	590	1320	4000	940	3015	10,800	5000	36,065	12.02	0.481	0.074
					50	6½	97,500	1220	350	1950	4500	380	860	5200	1220	4050	7,020	5000	31,750	16.35	0.326	0.050

ing effect, which keeps the maintenance charges low on the whole truck; a good tractive grip, and a reasonable cost are all properties which are required in a truck tire.

OPERATING COSTS

Fig. 2 gives a graphical view of percentage costs for a light-, a medium- and a heavy-weight truck, each averaging 50 miles a day. The higher proportion which the light truck has in the items of labor, depreciation and maintenance is noticeable. Against this increase is the lower percentage of the entire cost charged to fuel and tires.

In discussing motor-truck costs it is not possible to neglect the human factor, which here more than in most cases of machinery handling is one of the principal items. It is hardly too much to say that maintenance costs are chiefly driver. An expensive and intricate machine is put in charge of a low-paid employee who is not the owner and who ordinarily has but a limited knowledge of machinery. This is one reason why the life of a light truck is usually about two or three years.

Many of the larger department stores will not allow their drivers to make any repairs or even to carry a wrench or a pair of pliers. A repair force looks after each truck and keeps it cleaned, oiled and set up. Ownership of eight or ten

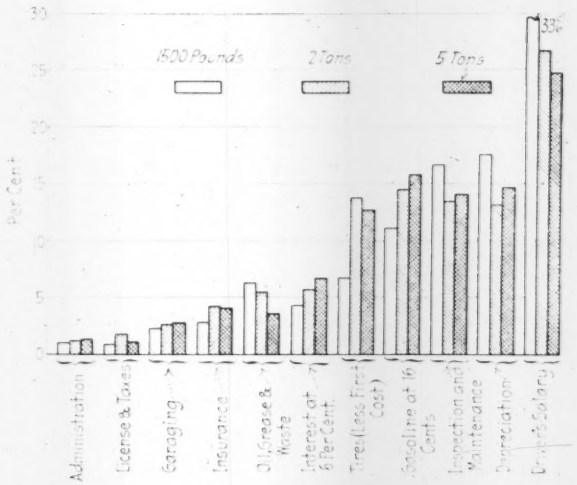

FIG. 2 DIVISION OF TRUCK COSTS

trucks will justify an owner in employing a mechanic who, with a small outfit of tools and a helper, can keep the trucks clean and in adjustment and make many of the smaller repairs. Reliable service garages are now to be found which will do the same work for a reasonable charge, and this is more satisfactory than to leave it to the driver.

It is impossible for the manufacturer to devise a shop test that will equal the brutality of actual service. The modern motor truck has had to meet the demand for a vehicle that will stand abuse. The careless or indifferent driver is quick to find this out. Operating costs for the same make and capacity of truck engaged in exactly the same kind of work for one firm will frequently show a variation of 40 per cent in the items of gasoline, oil, tires, and maintenance. It is easy to see how a poor driver will shorten the life of a truck.

Manufacturers have tried to meet this condition by making truck parts as few and simple as possible; by standardization of parts; by making wrong assemblies impossible; by printing detailed information about oiling and caring for the truck; and by instituting a follow-up service to get the truck owner started right. The truck governor has helped to solve the speeding problem. Another aid is a recording speedometer, which gives a graphical log of each day's run—velocity plotted against time: thus every minute of the day is accounted for; the number of stops and time of each, maximum speed, etc. The chart will show, for example, whether it will pay to put on a second man to hasten deliveries or whether a rerouting of existing lines will give a better all-around service. A driver's record sheet, if it is brief and informing and filled out each day, is frequently helpful. It must be drawn off at the office and kept up to date. Records are of little use unless changed conditions can be recognized at once.

Lubrication is probably the most important item in truck maintenance. Manufacturers have tried to make oiling simple and easy to do by making oiling places few and accessible, and

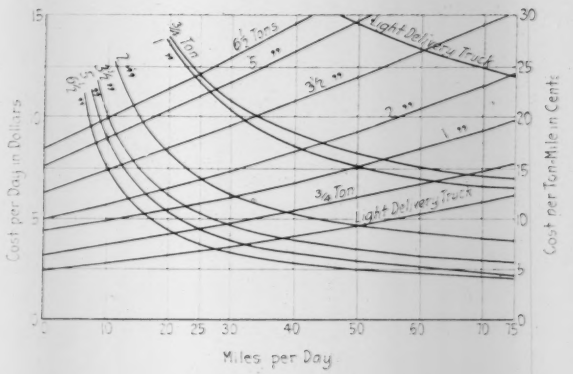

FIG. 3 COST OF OPERATING GASOLINE MOTOR TRUCKS

by providing charts and printed instructions for this work: some parts every day, some parts twice a week, etc. Still, there are about seventy places in the average truck that must be lubricated, and if there is no intelligent head to look after this work, local wear soon starts and then things go fast. Motor oil should be changed frequently, at least once for every 1000 to 1500 miles' run. It is not enough to build up the supply, as the oil is fast charged with carbon and with grit from the intake air and soon loses its lubricating qualities.

Fig. 3 gives curves for gasoline trucks plotted from the data of Table 1. These curves, if continued out to the line of zero miles per day, show the daily fixed charges for each truck. The cost per day increases quite uniformly with the increase in size of the truck, whether the daily run be a large or a small one. The cost per ton-mile is less for the larger trucks, and decreases quite rapidly as the daily mileage increases up to thirty or forty miles per day. The cost per ton-mile is based on a full load each way. This chart shows that under such favorable conditions of haulage a heavy truck may reach a ton-mile cost of as low as five cents, provided that the nature of the work is such that the truck can run daily at the rate of 50 or 60 miles a day. This is a heavy mileage for a big truck, and such an ideal service as would be represented by a full haul each way on level roads, with loading and unloading time minimized so that the truck could be under way for six or seven hours each day and with no extra helper required, is not often found.

In deciding upon a truck, one of the most important questions to settle is that of size. On the good roads of this section it is more disastrous to buy a truck too large for the work than to buy one that is too small. A 5-ton truck costs

some 25 per cent more to operate than a 3-ton machine, nor is this cost reduced very much by taking a lighter load on the heavier truck. Interest, depreciation, maintenance, taxes, insurance and fuel—all are higher. Until very recently the tendency has been for owners to buy trucks too large for their needs. Now the buyers have commenced to realize that it costs too much to "deliver the vehicle."

Another point that must not be overlooked is that the capacity of a truck is figured for average conditions, and that the average road condition throughout the country is very much harder on the truck than it is here. A half load on a truck carried over a road full of ruts and chuckholes is much worse for the truck than a 20 per cent overload on a good concrete or asphalt road. A 6½-ton truck recently carried an 11-ton casting up the Mount Wilson toll road, a distance of 9 miles. This is a tremendous overload, but it can not be said that the truck was injured by it. In fact, it is probable that the truck parts were not weakened in any way by this test, for the road, while steep, is firm and smooth.

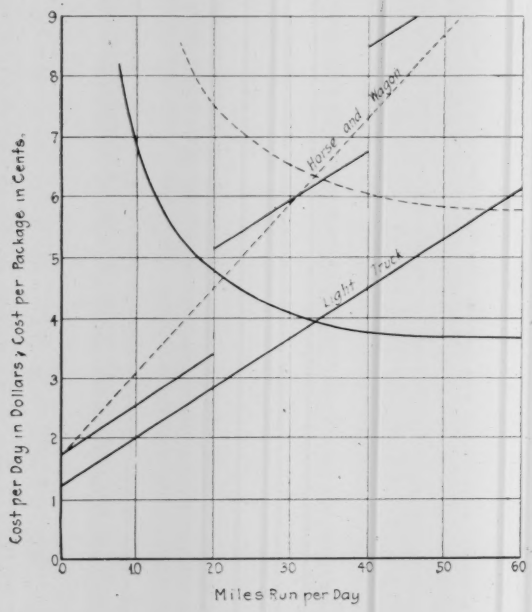

FIG. 4 COMPARISON OF SINGLE HORSE AND WAGON AND LIGHT DELIVERY TRUCK COSTS

The writer does not wish to encourage overloading, which has been responsible for many truck failures and against which much has been written, but he does wish to point out that an occasional overload of 25 per cent or even 50 per cent when handled carefully on a good road is not a serious matter, while to haul a heavy truck day after day, loaded at half capacity, is a very serious matter if one would haul cheaply.

It is possible to buy a truck that is suited for work on good roads or one that is especially designed for rough roads, mud, steep hills and severe service generally. The problem is to know what is suited and to weigh properly the arguments of the salesman who offers a 2-ton truck with a 15-h.p. motor and a 25-h.p. rear axle, and the counter arguments of his rival whose truck has a 25-h.p. motor and a 20-h.p. rear axle. This is one of the surprising results of the modern method of building up assembled parts into a truck, and while there may be advantages of such variations in the relative strength of truck parts for some particular service, it is a fact that both extremes are being sold for exactly the same work. The Society of Automobile Engineers has done a wonderful work in standardizing the parts for auto trucks. This will be carried much further in the future, for the economies that will result from standardized parts and also from standardized assemblies have been strongly emphasized by the experience of European countries with the use of trucks in the present war.

At present the truck owner or prospective purchaser is sadly in need of disinterested advice, and there is a good engineering field for the man who thoroughly knows trucks and can plan service. There is little doubt but that the average truck owner could save 20 per cent of his operating costs by properly analyzing his problem.

TABLE 2 COMPARISON OF OPERATING COSTS OF A SINGLE-HORSE WAGON AND A LIGHT GASOLINE DELIVERY TRUCK

Cost of wagon equipment (horse, $250; wagon, $140; harness, $40 . $430.
Cost of 700-lb. capacity gasoline truck, $600.

	Wagon Costs		Truck Costs	
	Idle	20 miles per day	Idle	60 miles per day
Estimated life, years	10	10	10	2.5
Depreciation	0.108	0.156	0.200	0.760
Interest at 6 per cent	0.086	0.086	0.120	0.120
Taxes	0.009	0.009	0.012	0.012
Stable or garage rent	0.200	0.200	0.166	0.166
Insurance (fire and theft)	0.030	0.030	0.045	0.045
Driver (⅓ time when idle)	0.666	2.000	0.666	2.000
Feed { Hay, 10 lb. and 15 lb.	0.102	0.153	.....	.....
Feed { Oats, 10 qt. and 15 qt.	0.200	0.300	.....	.....
Gasoline, at 16 cents per gal.	.....	.....	.....	0.640
Lubricating oil, at 40 cents	.....	.....	.....	0.130
Hostler (1 man to 12 horses)	0.200	0.300	.....	.....
Cleaning and oiling	.....	.....	.....	0.400
Shoes and veterinary	0.095	0.135	.....	.....
Tires and tubes	.....	.....	.....	0.625
Repairs to wagon	.....	0.090	.....	.....
Maintenance	.....	.....	.....	1.200
Water, bedding, etc	0.045	0.045	.....	0.005
Total cost per day	$1.741	$3.404	$1.209	$6.103

METHODS OF REDUCING TRUCKING COSTS

To get a low cost per ton it is necessary to keep the truck moving. Devices which cut down the time of loading and unloading are very important. Among these are self-dumping bodies of various kinds for stone, hot asphalt or lumber; loading chutes on bins which are filled by elevator or conveyor; there is also a movable steel tipple which can be run alongside a train of flat cars and be filled by shovelers while the truck is out on the road, so that the actual time required to fill the truck is very little. Another device is the use of extra truck bodies, which are loaded while the truck is on the road and swung onto the truck by an air lift or other hoist. A firm of wholesale grocers in Los Angeles is using this method very satisfactorily. In interurban delivery service loading nests or cartridges are being used. These are filled in the store and run out onto the truck. There is some promise in the extension of this device for relieving the congestion around freight stations and also for interurban service where a heavy truck can bring over all of the orders for an entire community and local deliveries be taken care of by light trucks each with its especial cartridge. A scheme somewhat similar to this is now being tried out by the City of Los Angeles. The incombustible rubbish is gathered by a house-to-house collection, using wagons. The material is put in large cans which are carried to a central point and a heavy truck is used to haul all of the cans to the city dump.

COMPARISONS OF OPERATING COSTS OF HORSE-DRAWN AND MOTOR TRUCKS

The use of an extra man to facilitate deliveries will often save enough time to make a good investment. One of the large department stores in Los Angeles found that on a certain route where one man had averaged 110 stops a day two men were able to make 190 deliveries. The use of self-starters on trucks of this type is also becoming common. These save a little time on each stop and also keep the driver out of the dirt, and particular customers appreciate this feature. At the plant of the Southern California Gas Company the night man unloads the trucks and stores the pipe and old meters that have been collected during the day, and then puts onto the truck the new supplies that have been requisitioned for the coming day.

Fig. 4 and Table 2 show a comparison between the cost of running a light gasoline delivery truck such as is used for close-in delivery work by grocers, and the cost of running a one-horse delivery wagon. The costs are from actual costs gathered in Los Angeles and vicinity and averaged. For each vehicle the cost is figured for the vehicle idle and again when running at a fair maximum daily average. The figures show that there is no excuse for using a horse for this kind of work, whether the number of deliveries be large or small. Twenty miles a day is a maximum for any delivery horse if used 300 days a year. If more than 20 miles a day are to be covered, it is necessary to duplicate equipment.

TABLE 3 COMPARISON OF OPERATING COSTS OF A 5-TON GASOLINE TRUCK AND A HEAVY TWO-HORSE WAGON

Cost of wagon equipment (2 draft horses, $600; wagon, $300; harness, $100), $1000
Cost of 5-ton gasoline truck, $4800

	Wagon Costs		Truck Costs	
	Idle	16 miles per day	Idle	50 miles per day
Depreciation	60	120	240	480
Interest	60	60	288	288
Taxes	6	6	30	30
Stable or garage	120	120	120	120
Insurance (liability)	...	26	...	140
Driver	250	750	360	1080
Helper	...	600	...	600
Feed or gasoline	90	135	...	686
Oil, grease, waste, etc	...	5	...	150
Shoes and veterinary, or tires	25	40	...	550
Repairs, maintenance	...	25	...	600
Water, bedding, etc	25	25	...	20
Hostler	100	100	...	...
Total cost (per year	$736	$2012	$1038	$4744
Total cost (per day	$2.45	$6.70	$3.46	$15.81

Fig. 5 and Table 3 give a similar comparison between the cost of operating a 5-ton gasoline truck and heavy teams used for such work as rock and dirt haulage and heavy transfer work generally. As in Fig. 5, the costs are figured from actual costs based on a maximum of service per day and an assumption as to what the costs would be if the vehicle did no work. The curves show that the truck should have enough work to do to occupy the time of more than one team, if it is to be the cheaper vehicle. The Pacific Electric Railway Company uses heavy trucks for patching the paving along the line. They find that for work outside the business district the truck will do the work of two to three teams, depending upon the length of haul and the size of the job; for long-distance hauling the truck will do the work of four or five teams.

In paving Vernon Avenue the rock and crushed stone were delivered by teams, the average haul being about two miles. Each team delivered a 3-ton load and averaged 5½ trips per day. When work on other contracts took the teams away, the work was sublet to another contractor who took the job at the same price per ton as the teams were figured to have cost. Three 5-ton trucks averaged 12 trips per day each, and carried an average of 54.7 tons per day apiece. This makes each truck equivalent to 3.3 teams, which would represent a considerable saving by the use of trucks, provided they could be kept steadily employed.

The use of electric trucks for delivery service is not so general in Los Angeles as in most large cities. Two of the largest department stores in Los Angeles use no electrics, and other stores which do use them have usually a smaller percentage of the entire fleet of this type. There are two reasons for this: first, a smaller congested area than cities like Boston or Chicago, and second, a smaller number of stops per mile. For light delivery service where the vehicles carry 1000 lb. or less the higher first cost of the electrics is a serious objection; for vehicles in the 1500-lb. class the difference in first

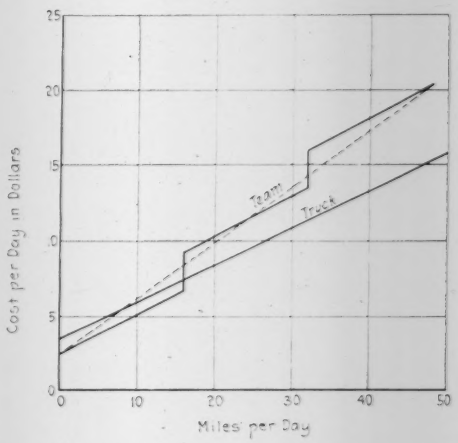

FIG. 5 COMPARISON OF COSTS FOR 5-TON GASOLINE TRUCK AND HEAVY TEAMS

cost is not so great, and the electric vehicle will show a lower cost per delivery than the gasoline truck where the latter is held down to the same number of miles per day. Table 4 gives the average work and costs for one month for both classes of vehicles for one of the large department stores in Los Angeles. From this it will be seen that where the electric truck gives a cheaper delivery, it has the advantage of more stops per mile. It is probable that in spite of the close-in traffic conditions the gasoline truck would cover the same route in less time or give a larger number of deliveries per day in the same territory. These costs are based on the use of two men with the gasoline truck and one man on the electric. The comparison shows that the advantage in favor of the electric truck is a very small one, and may vanish altogether under comparative tests. On the other hand, there is an advantage for the electric in its quieter operation and greater cleanliness that is worth something in delivery service.

TABLE 4 COMPARISON OF GASOLINE AND ELECTRIC DELIVERY TRUCKS
(Averages for 1 month)

Type of Truck	Gasoline	Electric
Miles traveled per day	75	36
Stops per mile	1.96	2.74
Stops per day	147	104
Cost per mile, cents	12	15.3
Cost per stop, cents	6.12	5.29

THE USE OF POWDERED COAL AS A FUEL

A Description of the Methods Employed in the Production, Handling and Firing of Powdered Coal, with a Discussion of Its Advantages when Used with Certain Types of Furnaces

By JOSEPH HARRINGTON, CHICAGO, ILL.

Member of the Society

POWDERED coal was under consideration as a fuel over twenty years ago, and its apparent advantages have attracted the attention of engineers ever since. The early experiments were naturally crude, and failed largely because of the lack of proper machinery for reducing the coal to the required state of fineness. It was not fully appreciated that the coal had to burn while floating in the air in the form of dust.

Sufficient experimentation was carried on, however, to prove that powdered coal would burn under these general conditions and would develop a particularly intense flame. In fact, one of the chief difficulties encountered was the melting down of the furnace due to the blast-like effect of the jet of coal and air.

After the early failures there was very little done for a number of years, but about five years ago the matter was revived, and with the development of adequate pulverizing machinery, extensive and practical applications have been made.

The first general field of usefulness to which it was applied was the burning or clinkering of cement. The coal was not required to be pulverized particularly fine. The velocity of the jet of coal and air entering the kiln could be high, and little or no difficulty was encountered from deposits of slag or ash. The next general application of this fuel was in the simpler metallurgical processes in the heating furnaces, where excessive temperatures were not required and where the ash deposits were either continuously removed with the material to be heated or could readily settle on the hearth and be later withdrawn.

In 1912 the American Iron & Steel Manufacturing Company had carried their experimentations to a point where they were ready to publish statements of the successful use of the fuel. At the Lebanon plant they have used it in puddling and heating furnaces and small reheating furnaces for nut, bolt, and spike bars, and in larger furnaces for continuous billet heating and open-hearth melting.

REQUIREMENTS OF PULVERIZATION

The condition in which this fuel must be furnished to produce satisfactory results has been developed to a point where it can be considered as definitely standardized. Not only for the sake of combustion efficiency but for the sake of more perfect pulverization the coal should be practically dry, 1 per cent of moisture being the maximum amount at which pulverizing can properly be effected. One-half of 1 per cent moisture is the figure which is ordinarily required. Under these conditions the coal when pulverized remains quite fluid, and will break down under the influence of the crushing rolls with much less expenditure of power than when damp.

In order that the fuel may remain suspended in the carrying air and in the furnace chamber during combustion, it is necessary to reduce it to a certain degree of fineness. After a great deal of experimenting this standard has been established as follows: 85 per cent must pass through a 200-mesh screen and 95 per cent must pass through a 100-mesh screen. When these requirements are fulfilled there is an indeterminate amount of impalpable product, the absolute size of which it is beyond our ability to measure.

Much has been printed regarding the quality of coal most suitable for pulverization, but no arbitrary limits can be established as to the proximate analysis most suitable. Broadly speaking, the greater the volatile combustible content the more readily will the coal ignite and burn, and the less dependent will be this process upon the size and proportions of the combustion chamber. As the volatile content decreases, however, more dependence must be placed upon the proportions and location of the surrounding brickwork, in order to maintain the temperature until ignition is complete. Anthracite coal has been burned in a pulverized form, but it must be very finely ground and must be burned in a rather confined space, so that the ignition may be prompt and aid be rendered by nearby brickwork during the early stages of combustion.

PULVERIZING MACHINERY

Several types of machinery which are commercially marketed will satisfactorily pulverize coal. They are divided broadly into air-separation machines and screen machines. In the former class there is an upward current of air produced by a fan which has a carrying capacity sufficient to take with it the finest particles, but which will not lift the coarser ones. As soon, therefore, as the coal is reduced to the required degree of fineness this air current will lift the particles and take them away and will then deposit them in a receiving tank by means of a cyclone separator, which is usually vented in some manner to prevent the loss of dust.

In the screen mill the coal is continually thrown against a screen which permits the fine particles to pass through but causes the coarser particles to fall back under the rolls. Pulverization can be effected in a tube mill or ball mill with an expenditure of power and cost not greatly different from that of the other types.

THE BURNER

The pulverized fuel being collected in a hopper is conveyed either by screws or pneumatic means to the burner, which is situated at the furnace to be served. As to this particular appliance there is great divergence of opinion and a greater variety than at any other point of the entire system. It is now generally conceded that the most efficient results are obtained when the coal dust is carried into the furnace in a stream of air, the volume of which is just sufficient to supply the oxygen necessary for its complete combustion; the velocity

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of the entering jet must be greater than the rate of flame propagation to prevent burning back into the pipe.

This mixture of coal and air must be made in fairly close proximity to the furnace. The reasons therefor are that when this mixing is done there is produced an explosive compound, which it is desired should not be of any greater extent than necessary. The other reason for making the explosive mixture close to the furnace is that there is a tendency for the coal to separate and lose its uniformity of mixture, under which condition it is obvious that part of the jet would be oversupplied with coal, and the other part oversupplied with air. The production of this uniformity is the more important and difficult, and is the rock on which have been wrecked the hopes of more than one enthusiastic experimenter. Various devices have been provided for producing and maintaining the required uniformity of mixture.

In the existing commercial installations the fuel is removed from the storage hopper by means of a screw of special design. This screw is placed at the bottom of the hopper and is usually driven by some form of variable-speed device, thereby securing control over the amount of coal extracted per unit of time. It is a well-known fact that the delivery from such a screw is not uniform, the coal being delivered in little heaps and producing distinct pulsations in the furnace. To reduce this effect these screws have been made with a double or a triple helix, in which case two or three discharges per revolution are produced in place of one. This is a distinct improvement, of course, but even under these conditions a very noticeable pulsating effect is observed. Devices have been developed for passing this discharged material over a screen, or over a moving disk operated at a considerable speed, the idea being to smooth out the inequalities and produce a continuous delivery of dust. Some of these devices have proved their ability to secure this effect, which is all-important on account of its direct influence on the character of the flame in the furnace. Once established this uniformity must be maintained, and if it be necessary to have the mixer at any considerable distance from the furnace, means must be provided for uninterrupted agitation of the air current in order that the fuel cloud may remain of constant density. This is not a very difficult matter, but is one which must not be overlooked.

OBJECTIONS AND DIFFICULTIES

As is the case with all new things, the early history of the use of powdered coal is replete with accounts of failures, and this has left an impression on the minds of the engineering public which it will take years of successful application to eradicate. The early experimenters did not understand the necessity of fine grinding, and it would seem that they did not appreciate the influence of furnace design upon the temperature of the resulting gases. The coal was powdered sufficiently fine, however, to develop intense temperatures, even though part of the coal was lost by falling to the bottom of the furnace and being thus removed with the slag and ash.

Insufficient combustion space and the ease with which this fuel can be mixed with the minimum amount of air, combined to produce abnormal temperatures and a direct contact of flame and brickwork. The blowpipe effect of the high-velocity jet acted to melt out the brickwork upon which it impinged. A layer of melted lava, formed by the fusing of both ash and brickwork, accumulated in the bottom of the combustion chamber, and naturally discouraged those who depended upon this fuel for continuous service.

Later on, difficulty was encountered due to the minute particles of liquid slag being carried on in suspension and deposited upon the tube sheet or water tubes of the boiler, thereby closing up the flame space and putting the boiler out of action. These effects are particularly observable with certain grades of coal, but noticeably absent with others; and only until recently has research work been carried to a point where any knowledge has been obtained of what causes this trouble and what coals are most suitable for firing in powdered form.

ADVANTAGES

Having stated the objections, it is interesting to pay equal attention to the advantages of this fuel. Inasmuch as these advantageous features form the foundation of all discussions of this subject, as well as the impelling cause of all experimental work, I will but merely restate them, depending upon later paragraphs to develop the subject more fully.

From the viewpoint of the theorist, the use of powdered coal forms one of the best methods ever proposed for the promotion of combustion efficiency and commercial economies. In all transformations of energy there is unavoidable loss, and we are not possessed of apparatus which will gasify coal with 100 per cent efficiency. In the producer there is a succession of losses which reduce the available heat in the gas to a considerable extent, and in the mechanical stoker there are unavoidable losses due to various forms of incomplete combustion. Only in the case of powdered coal is the actual solid fuel both gasified and completely consumed directly within the chamber desired to be heated. With perfect pulverization the entire mass is burned in suspension, and in actual practice but a small fraction of one per cent is actually lost in the flue dust or slag pan.

On account of the fuel being conveyed into the furnace by the very air which is afterwards to be used in its combustion, and on account of the diffusing of the coal throughout the air in a cloudlike formation, there is a possibility of a mixture which can be secured by no other means. Each particle of coal is surrounded by a particle of air, and on account of the extreme fineness of the particles practically instantaneous oxidation occurs. The result is efficient combustion, and we have to deal only with the effects of the high temperature thereby obtained. That it is now possible to control this temperature while not sacrificing any material gain due to it, is definitely established. Moreover, the definite control of the amount of air per unit of coal permits of the most perfect variation in the results obtained. It would be impossible herein to enumerate in detail all of the means employed to take advantage of the inherent efficiency of this form of firing.

POWDERED COAL FUEL IN STATIONARY PRACTICE

It must be confessed, I think, that steam generation by the use of powdered coal as a fuel is still in the experimental stage, and here if anywhere will it meet severe competition. With the exception of the M. K. & T. installation at Parsons, Kansas, which is now being put in by the Fuller Engineering Company, all of the steam-making installations are in the plants of the manufacturers of powdered coal equipment, or in plants very directly connected therewith. That steam can be efficiently produced in this way is unquestioned if merely combustion and evaporation are considered. Whether it can be generated more economically than it is at present by plants with the best mechanical stokers, still remains to be commercially proved, and even with powdered coal, gas analyses better

than 16 per cent of CO_2 are not developed. With the mechanical stoker the CO_2 can be maintained around 14 per cent.

With powdered coal the loss in the ash pit and in the flue does not exceed 1 per cent, and with the best mechanical stokers this loss will not exceed 2 per cent of the coal fired. A possible advantage of 2 or 3 per cent in combustion efficiency in favor of powdered coal is offset by the cost of fuel preparation. It is not reasonably to be anticipated that we can get better than 96 per cent efficiency, and this is a figure which can be obtained by the mechanical stoker. I foresee, therefore, a hard fight for powdered coal in stationary steam-boiler practice.

POWDERED COAL FUEL IN LOCOMOTIVE PRACTICE

On account of the very comprehensive and detailed report on this subject which has today been presented at the Railway Fuel Association meeting, and its availability in printed form, I will not attempt to enlarge upon it here. It is in cases such as the locomotive that powdered coal shows most favorably. Here we have not only the single problem of combustion efficiency, but a long list of related conditions that are affected thereby. I can do no better than to quote the summary of the report of the standing committee of the Railway Fuel Association.

Summing the results that are being obtained in locomotive service these may be stated as:

1 Smokeless, sparkless and cinderless operation.
2 Maintenance of maximum boiler pressure within a uniform average variation of 3 lb. without popping.
3 An increase of from 7½ to 15 per cent in boiler efficiency as compared with burning lump coal on grates.
4 Saving from 15 to 30 per cent in fuel of equivalent heat value fired.
5 Enlarged exhaust nozzle area, resulting in greater drawbar pull and smoother working of the locomotive.
6 Elimination of ash-pit delays, facilities and expenses, and reduction in time required for, and ease in, firing up.
7 Maintenance of a relatively high degree of superheated steam.
8 No accumulation of cinders, soot or ashes in the superheater or in the boiler flues, smokebox, or on the superheater elements.
9 No punishment or overheating of the firebox, new or old sheets, seams, rivets, patches, bolts, stays or flue beads.
10 Elimination of arduous manual labor for building, cleaning and dumping fires, and for firing. This feature would appear to be quite advantageous, due to difficulty experienced in holding satisfactory labor on this class of work at the rates usually paid.
11 Avoidance of expense and annoyance in providing various sizes and kinds of fuels.
12 Elimination of front end and ashpan inspection and special fuels, firing tools and appliances for building fires and for stoking and cleaning them.

Your committee is of the opinion that the effectiveness and utility of the use of fuel in pulverized form has been demonstrated from the past year's development, and that the progress in the use of this method of stoking and burning bituminous and anthracite coals and lignites for generating power, heat and light on railways will be quite marked from now on.

The constantly increasing cost of railway fuel at the mine; the scarcity of fuel oil; the domestic and export demand for the larger sizes of coal; the prohibitive cost for briquetting the smaller sizes of coal and of lignite for railway use; the payment of labor on the run-of-mine basis for mining bituminous coals; and the necessity for eliminating smoke, sparks, and cinders, will all tend towards the inauguration of this practical means and method for increasing the efficiency of steam-boiler operation, which today affords the greatest opportunity for improving locomotive and power-plant costs and performance, and for changing public sentiment by smoke abatement.

ASH FUSIBILITY

A phase of the combustion problem both in connection with powdered coal and mechanical stokers, which is but now receiving adequate attention, is the study of the temperatures and conditions under which ash will melt. Engineers have always recognized the fact that certain coals were greater clinker producers than others, and this was laid at the door of the sulphur content. Recent experimental work, however, has shown that the sulphur is not the controlling element, although the exact causes are not yet sufficiently well known to be definitely stated.

Coal ash will melt at temperatures between 2200 and 2700 deg. fahr. Furnace temperatures in commercial practice run between 1800 and 2800 deg., so that it is possible to secure coals the ash from which will pass through the furnace without fusing. Under these conditions absolutely no clinker for-

TABLE 1 COST OF COAL-PULVERIZING PLANTS AND COST OF PULVERIZATION

This table is based on the following data:
Labor rates per hour: Millers, $0.20; drier firemen, $0.175; common labor, $0.15.
Cost of drier fuel, $0.03 per net ton. (Based on coal with 7 per cent moisture at $2.60 per ton, delivered, and 6 lb. evaporation per lb. of coal burned.)
Repairs, $0.05 per net ton. (This includes whole pulverizing plant, covering all machinery.)
Power, $0.102 per net ton pulverized. (Based on consumption of 17 hp-hr. per ton pulverized and cost per h.p. per annum of $45.00.)
Interest and Depreciation based on 10 per cent of cost of plant and 300 days' operation per year.

Daily Capacity, Net Tons	Total Cost of Pulverizing, Cents per Ton		Cost of Plants, Including Buildings, Dollars	Number of Men Required	Number and Size of Fuller Mills Required	Labor Cost, Cents per Net Ton
	Interest and Depreciation not Included	Including Interest and Depreciation				
5	70.0	....	4,000 [1]	1	1—24-in.	45.00
10	48.2	96.3	14,500	1	1—33-in.	30.00
20	37.4	61.9	14,500	2	1—33-in.	20.00
30	35.8	51.8	14,500	2	1—33-in.	17.40
40	33.6	47.0	14,500	2	1—33-in.	15.30
50	32.0	44.1	18,150	3	1—42-in.	13.80
60	31.0	41.4	18,150	3	1—42-in.	12.75
70	30.2	37.8	18,150	4	1—42-in.	11.85
80	29.3	36.7	18,150	4	1—42-in.	11.10
90	28.4	36.4	18,150	5	1—42-in.	10.25
100	27.7	36.2	25,620	5	3—33-in.	9.50
110	27.0	34.7	25,620	6	3—33-in. [2]	8.80
120	26.4	33.5	25,620	6	3—33-in. [2]	8.30
130	25.8	32.9	25,620	7	3—33-in. [2]	7.69
140	25.4	31.5	26,150	7	2—42-in.	7.14
150	25.0	30.6	26,150	7	2—42-in.	6.80
160	24.7	30.0	26,150	7	2—42-in.	6.50
170	24.5	29.6	26,150	8	2—42-in.	6.20
180	24.3	29.1	26,150	8	2—42-in.	6.00
190	24.0	28.5	40,130	8	3—42-in.	5.92
200	23.9	31.0	40,130	9	3—42-in.	5.75
210	23.8	30.5	40,130	9	3—42-in.	5.47
220	23.7	30.4	40,130	9	3—42-in.	5.22
230	23.6	30.2	40,130	9	3—42-in.	5.00
240	23.5	30.1	40,130	10	3—42-in.	5.00
250	23.4	30.0	40,130	10	3—42-in.	5.00

[1] Cost of building not included.
[2] Two 42-in. mills have the same daily capacity.

mation is encountered, and the coal is rated as satisfactory from this standpoint. In exactly the same furnace another coal will clinker badly and give trouble. There is no hard and fast rule, therefore, which can be stated for the selection of a coal.

The temperature obtained in service, which is a function of the rate of combustion, the amount of excess air, and the proportions of the furnace chamber, must be determined, and analyses of the fuel made to determine whether or not it will be suitable under the given conditions. Like many other scientific investigations, the value of a few dollars spent in this manner is not always appreciated, and the user will tolerate the formation of clinkers for months before he turns to another source of coal supply. When he does so, he may or may not solve his problem, and it becomes necessary to purchase and consume a variety of coals before one is found which is suitable to his needs.

TABLE 2 COST OF PULVERIZING COAL AT THE ALLENTOWN (PA.) PORTLAND CEMENT COMPANY FOR THE YEAR 1914

(Gross tons ground in year, 37,523)

		Cost per Annum	Cost per Gross Ton
Operating	Labor	$3786.72	$0.1008
	Material	161.04	0.0042
Driers and Elevators	Repair. Labor	584.24	0.0155
	Material	512.40	0.0136
Pulverizing Mill Repairs	Labor	84.84	0.0022
	Material	428.88	0.0114
Electricity: Labor and Material		37.16	0.0009
Belts: Labor and Material		79.73	0.0021
Power		4096.73	0.1091
Total Cost		$9771.74	$0.2598

(Cost per net ton, $0.2324)

In powdered-coal work, with the more precise and scientific manner of the combustion process, the necessity for proper knowledge of the point of ash fusibility is greatly increased. The day is rapidly approaching when the burning of coal will be considered a precise scientific chemical reaction, in which the elements are supplied with exactness and understanding, and the result obtained, corresponding in definiteness to the precision of the mixing process, will be made to conform exactly to the requirements of the service.

The Commercial Testing & Engineering Company has determined that washing a dirty coal has no effect on the fusing point of the ash, so that mere ash content is not the determining factor of desirability when considering a coal for pulverization. The importance of this preliminary investigation can scarcely be overstated. Assuming a malleableizing oven, wherein the temperature does not exceed 1800 deg., it is quite obvious that this is below the melting point of ordinary ash, and aside from the objection to a large volume of ash, any coal can be used.

Considering a furnace of higher temperature requirements, such as a billet-heating furnace where, say, a temperature of 2300 deg. is desired, it is obvious that a coal fusing at 2500 deg. would be entirely satisfactory, whereas one fusing at less than 2300 deg. might cause clinker formation. In the case of still higher temperature work only those coals which have the highest fusing point could be used, unless ample provision were made for the accumulation of fluid ash.

CONCLUSION

My general conclusion as to the future of powdered coal as a fuel is briefly this: Powdered coal is radically different in its physical structure and method of handling from any other form of coal heretofore commercially used. Having marked characteristics it will fit into certain cases with extreme acceptability, and will probably prove just as undesirable in certain other cases. Probably the most important difference is the burning of the actual solid fuel directly within the chamber and in direct physical contact with the metal to be heated. There is, of course, an appreciable amount of incandescent carbon in the furnace at all times, and this solid fuel is emitting radiant heat in close proximity to the furnace contents. A large amount of the radiant energy is therefore directly utilized, which is not the case when coal is gasified in a detached chamber. I cannot but conclude, therefore, that the success of powdered coal lies in its adaptability to the special furnaces of the metallurgical field, and in those cases similar to the locomotives, where there are other and weighty considerations in addition to the actual relative increase in combustion efficiency.

PULVERIZED-FUEL INSTALLATION SERVING TEN 250-H.P. O'BRIEN BOILERS

By H. G. BARNHURST, ALLENTOWN, PA.

Member of the Society

AT the Parsons (Kan.) shops of the Missouri, Kansas and Texas Railway Company an installation for preparing and burning pulverized low-grade coals, including lignite, under boilers is now being completed, which is the first and largest commercial installation of its kind in existence.

The boilers in the plant (O'Brien, 250-h.p.) are arranged in one continuous row of three and one batteries, respectively, there being a space between the settings of each pair of two boilers of 4 ft. 8 in., and a space between the two batteries of 28 ft. 4 in. for feed pumps, auxiliaries, etc. At the far end of the battery of two boilers space is allowed for four more boilers, which will then make twelve in all. Eight boilers are now installed, and equipment is supplied for ten.

The boilers are to carry 150 lb. steam pressure, the feed water being delivered to the boilers at 208 deg. fahr. Based on a boiler efficiency of 70 per cent, operating full capacity for 10 hours and half capacity for 14 hours, about 158,000 lb. of coal will be consumed in 24 hours, or 79 net tons for the ten boilers. When the two additional boilers are added, a total of 94 tons per day of 24 hours will be required. Two 42-in. Fuller mills operating 12 hours per day will readily produce 96 to 100 tons of pulverized coal, which will be more than ample for this plant.

Written discussion of paper entitled "The Use of Powdered Coal as a Fuel," presented at a meeting of the Chicago Section of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS, May 15, 1916.

THE PULVERIZING PLANT

The coal which is used in this plant is dumped directly from the cars into a concrete and steel hopper beneath the track which runs parallel and adjacent to the power house and coal plant. As a large percentage of it will be mine run, a 20 by 24-in. spike-toothed roll crusher is placed directly beneath the hopper discharge to break down the large lumps it contains. This crusher is driven by a belt-connected motor, 15 in. centers, placed in the inclined tunnel leading from the track hopper to the coal plant, a building 43 by 54 ft.

A 20-in. belt conveyer, with its receiving end directly beneath the discharge from the toothed roll crusher, conveys the coal through an inclined tunnel to the coal plant, the near wall of which is 25 ft. from the center of the track hopper, this distance being determined by the difference in height of the receiving and delivery ends of the belt conveyor. At the delivery end of the belt conveyor a 24 by 22-in. magnetic separator pulley is placed to hold and remove any tramp iron that will be brought along with the coal, and the coal is then discharged into a pair of 24 by 18-in. corrugated rolls driven along with the belt conveyor by a motor of the belted type.

From the corrugated rolls the crushed coal is carried up in an elevator, discharged into a screw conveyor and carried along to a bin over the back end of the drier. This bin has a capacity of 40 tons, which allows a storage ahead of the drier and mills of five hours. The elevator and screw conveyor are both run by one motor.

THE CONVEYING MACHINERY

From the bottom of the bin a screw conveyor feeds the coal to the back end of a 4½ by 30-ft. indirect-fired rotary drier, both being run by one motor.

The coal passes through the drier and is discharged to an elevator at the front end. A screw conveyor located in the floor also carries the tailings from the settling chamber beneath the drier stack to the elevator. The dried coal and tailings are elevated, discharged into a screw conveyor, and carried to the bin over the pulverizer. This bin is placed in front of and high enough above the mills to enable all the coal to be fed to them by gravity, and has a capacity of 45 tons. The elevators and conveyors over the bins are operated by one motor. There are two pulverizers.

The pulverized coal is delivered by spouts from the pulverizer mills directly to an elevator and raised to a screw conveyor which carries the coal to the boiler house. The conveyor and elevator are both operated by one motor. This conveyor is carried over a bridge 30 ft. long between the coal plant and boiler house, and continues on through the entire length of the power house over the bins in front of the boilers, thus making a single straight-delivery unit from coal plant to bins about 216 ft. in length.

One bin is placed in front of each pair of boilers. These bins are rectangular in shape but have divided hopper bottoms, thus enabling the coal to be fed by separate feeders to each boiler. Each half of the bin with its hopper bottom will hold 10 tons of pulverized coal, which will provide storage in front of each boiler for a run of 20 hours at full capacity. This allows ample capacity, so that any delay in the coal mill proper will not interfere with the continuous operation of the boilers for a period of over 24 hours if the boilers are run under ordinary operating conditions. Each bin is filled through three separate gates with spouts in the bottom of the conveyor, so that the supply to any bin can be controlled as desired.

AIR BLAST FOR FEEDING THE COAL

Underneath and between the sides of the inverted "V" formed by the two hoppers of the bin is placed a direct-connected motor-driven fan with a down-blast discharge which is divided into two 7-in. blast pipes. These two pipes diverging at an angle of 60 deg. with each other coming down in a plane parallel to the front of the boilers, about 8 ft. from the front wall of the firebox or combustion chamber, make an easy sweeping bend and discharge into the burner nozzle located in front of each boiler 3 ft. from the floor. The fan supplies the air needed in feeding the coal (4200 cu. ft. per min.) at 3 oz. static pressure to a burner nozzle in front of each boiler.

At the bottom of each of the two hoppers of each bin is a 4-in. screw feeder enclosed in a circular cast-iron casing. Above each feeder, between the hopper and the screw proper, is a slide, so that if for any reason the feeder should become jammed or broken it could be readily removed without first drawing the coal from the bin. Each feeder is chain-and-sprocket-driven by a 2-h.p. variable-speed back-geared motor, the controlling rheostat of which is located in a convenient position in front of the boilers.

THE BURNERS

Each feeder discharges into a 3-in. pipe, 8 ft. long, which drops the coal straight down and into a funnel-shaped opening in the top of the burner nozzle. This burner is ideal for the purpose, as it is both simple and highly efficient. It consists of an outside 14-in. cylindrical pipe, one end of which projects into the furnace; into the other end the 7-in. blast pipe is inserted and extends inwardly from 12 to 18 in. A metal cone is fitted over the blast pipe so that it can be moved back and forth any desired distance, thus forming a valve to regulate the amount of air that is induced in the burner or to close the opening entirely if desired. Directly over the inserted end of the blast pipe a small funnel-shaped cone is placed in the outside pipe, into which the coal is fed and drawn in by the suction formed by the blast. The funnel opening into which the coal is fed is directly over the discharge end or nozzle of the blast pipe, so that the coal will be drawn in and thoroughly mixed with the blast and induced air before reaching the combustion chamber of the furnace.

A large quantity of air can be induced in this burner, which, together with that blown in by the fan, will supply all the air required for combustion. The blast pipe is provided with a 2-in. screw-capped opening just back of the sliding cone, so that the pressure and velocity of the air can be determined when desired. The outside burner pipe is also provided with two similar openings, one between the coal opening and the open end, and the other about 1 ft. from the furnace wall.

At normal rating on a basis of 70 per cent efficiency and with feed water at 208 deg. fahr., these boilers will each consume 958 lb. of coal per hour or 16 lb. per min., and will therefore require about 3200 cu. ft. of air per min. for combustion. Half of the capacity of the fan (or 2100 cu. ft.) will be supplied through the 7-in. blast pipe to each boiler, the remainder being induced by the action of the blast in the intake end of the burner.

THE FURNACES OR COMBUSTION CHAMBERS

The furnace or combustion chamber of these boilers is well adapted for firing with pulverized coal, in that it has 583 cu. ft. of volume or, at normal rating, 36.4 cu. ft. per lb. of coal fired per min. The bridge wall is located 7 ft. from the front wall of the setting and from the end of the burner. The baffle wall, which in the standard O'Brien boiler is carried on the bottom row of tubes, has in this case been replaced over the combustion chamber with bricks, with a U-shaped opening in one side to fit the tube so that when inserted the two together will completely surround the bottom of any tube, and thus serve to protect the tubes from the direct action of the flame and likewise offer a combustion chamber whose top, bottom and sides present to the entering coal dust a surface entirely lined with highly refractory firebrick, the top or roof being protected by the tubes. From the base of the arch wall, on a level with the floor of the boiler room, the bottom of the combustion chamber slopes downward toward the front at an angle of 45 deg. till it reaches a point directly under the front setting, where a shelf 2 ft. wide projects straight out to a door in the ash tunnel through which steel cars are operated and into which the ash and slag which is precipitated on this shelf is raked. The bottoms of these ash doors are located 7 ft. below the floor of the boiler room, and the tops of the cars just come to within 3 in. of this level, so that all that is necessary is to move the car in front of the ash door. The sides of this sub-combustion chamber extend vertically downward from the floor level for a distance of 3 ft. 6 in. and then converge toward the center at an angle of 53 deg. with the vertical until they meet the above-mentioned bottom shelf 2 ft. apart, so that the bottom of the furnace or combustion chamber forms a firebrick-lined hopper with a bottom 2 ft. square. The remaining front wall of the furnace is, of course, extended straight down to 3 ft. 6 in. below the floor level and cut under in a sloping arch parallel to the rear side so that it will form a sloping roof to the top of the ash door.

The area between the top of the bridge wall and the bottom row of brick-protected tubes is 19 sq. ft., and with a temperature in the furnace of 2800 deg. the velocity of the gases over the bridge wall at normal rating will be about 16 ft. per sec. With such a low velocity it can be readily seen that the greater part of the process of combustion should be completed before the gases pass over the wall, and also that a large percentage of the ash or slag will be deposited in the hopper bottom. There is also a settling chamber back of the bridge wall, and any ash that settles in this chamber can be raked out of a door at the side.

APPENDIX

Since this discussion was submitted, the plant has been put into successful operation, and developments have made it advisable to alter the furnace design somewhat.

With Kansas coal containing approximately 22 per cent ash, the horizontal baffles allowed too much ash accumulation, so a Dutch oven approximating a 6-ft. cube was built in front of each of two boilers and vertical baffles were inserted, replacing the former horizontal ones. With these changes highly gratifying results are being obtained. No slag is formed, and the ash is readily blown off the floor of the rear chamber with an air hose once a week.

No part of the refractory lining is subjected to an excessive temperature even at considerable overload.

The Missouri, Kansas and Texas R. R. officials are very enthusiastic concerning the operation and economies being obtained both with the aforementioned 22 per cent ash coal and also with lignite, and the Dutch ovens and vertical baffles are being installed as promptly as possible for the other boilers.

The operation is quite flexible and by the most simple adjustments almost any furnace conditions can be realized, the capacity being varied at will.

The density of liquid hydrogen, according to the most recent determination—that of Dr. H. Augustin (*Annal. Physik.*, vol. 46, p. 415), is 0.07105 at—252.83 deg. cent. and 745.52 mm. pressure.

At a recent meeting of the American Drop Forgings Association the Holbeck system of burning pulverized coal in forging furnaces was described. It was stated that 10 lb. of pulverized coal are equivalent to 1 gal. of fuel oil, and with the former at $3 per ton the equivalent in fuel oil would mean oil at 1½ cents per gal. Also, that 75 lb. of coal dust are equivalent to 1000 cu. ft. of natural gas, or that $3 coal is on a parity with 12-cent gas.

The best composition for condenser tubes operating with fresh, unpolluted water is believed to be 70 per cent copper and 30 per cent zinc, as it has the maximum ductility of all brass compositions, gives a greater promise of adequate cold working and annealing, and, having but one metallagraphic constituent, the possibility of electrolytic action is precluded. The heat treatment of condenser tubes should consist in annealing each tube between each pair or set of cold drawings, at a temperature high enough to remove the grain distortion caused by the cold drawing, but not at such a temperature as will permit crystalline growth to take place that will result in coarse crystallization. After the final drawing each tube should be annealed just enough to break down the distorted structure produced by that drawing.—A. E. White, in a paper read before the American Society for Testing Materials, June 30, 1916.

An air-lift well-pumping installation of the Talbot type at the Camden (N. J.) Waterworks has, it is stated in the *Engineering Record* of June 3, 1916, developed on test an overall efficiency of 59 per cent, measured between the steam end of the compressor and the point of delivery of the water. The well was 120 ft. deep and 8 in. in diameter, the water reduction pipe 5 in. in diameter and fitted with an umbrella deflector at the top, and the air pipe 1¼ in. in diameter. The depth to the foot piece was 106 ft., and from the umbrella to the foot piece 115.5 ft. Certain of the test results are as follows:

Gallons pumped per minute.....	300	322	392
Cubic feet of free air per minute...	50	60	100
Efficiency, per cent.....	59.6	54.2	40.2

These show a steady falling off in efficiency as the air supply is increased and more water is pumped, which is to be expected (1) because of the lower submergence when pumping the larger volume and (2) because of the greatly increased friction of water and consequent slippage of air at the higher velocities of discharge. This friction and slippage, it is held, may be considered as the chief causes of inefficiency in most air-lifts.

CORRESPONDENCE

CONTRIBUTIONS to the Correspondence Departments of The Journal by members are solicited by the Publication Committee. Contributions particularly welcomed are suggestions on Society Affairs, discussions of papers published in The Journal or brief articles of current interest to the membership.

STRENGTH OF BOILER FURNACES

TO THE EDITOR:

The conventional engineer's theory on the strength of a lap joint assumes the stress uniformly distributed over the cross-section, either in the solid plate or between rivets, and ignores eccentricity of loading due to plates being out of line. Probably none will dispute the fact that a lap joint is considerably weaker than it is supposed to be, due to this neglected eccentricity of loading, but just how much weaker is considered debatable.

A comparison, by means of a concrete case, of the A.S.M.E. Boiler Code formula for the strength of boiler furnaces with other formulae shows that the former gives working pressures far too high.

Consider a flue of 29 in. external diameter made of ½-in.

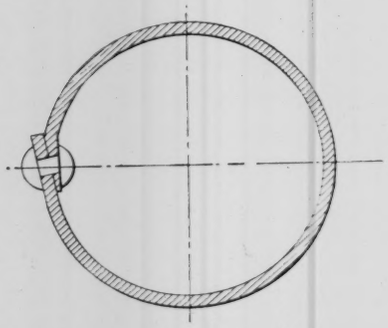

FIG. 1 FORM OF LAP JOINT TO MAINTAIN TRUE CIRCULARITY

steel plate with a single-riveted longitudinal lap joint; the length is 94 in.

In the following the permissible working pressure for this flue is computed by various formulae and arranged in order of decreasing magnitude. If a particular formula does not apply to *jointed* flues, then the value obtained as working pressure is multiplied by the efficiency of a single-riveted lap joint for purposes of comparison with the A.S.M.E. formula. If the formula permits a double-riveted lap joint, say, then the working pressure obtained is reduced in the proportion of the efficiency of a double-riveted lap joint to that of a single-riveted lap joint. These efficiencies are taken as 77.6 per cent and 63.3 per cent, respectively.[1] These figures represent the maximum possible efficiency, considering a perfect joint and accepting the A.S.M.E. Boiler Code values for unit stresses. This causes the Boiler Code formula to show up as favorably as possible.

A.S.M.E. Boiler Code Rule. This permits any kind of joint, hence the weakest possibility, viz.: a single-riveted lap joint is taken in the other cases for purpose of comparison. The efficiency of the joint is, however, always taken as the maximum possible, as stated above.

In the case considered, as the length exceeds 120 times the thickness, the second formula given in the Boiler Code must be used, viz.:

$$P = \frac{4{,}250T^2}{LD}$$

where P = maximum allowable working pressure, lb. per sq. in.
D = outside diameter of furnace in in.
L = length of furnace in in.
T = thickness of furnace wall in sixteenths of an inch.

whence

$$P = \frac{4{,}250 \times 8^2}{94 \times 29} = 99.8 \text{ lb. per sq. in.}$$

Fairbairn's Rule. This formula does not allow for joint. Fairbairn's rule, although the parent formula, is recognized as giving working pressures far too high if the present-day factor of safety of 5 be employed.

$$p = \frac{806{,}300 \times t^{2.19}}{LD}$$

,

where t = thickness of tube in in.
L = length of tube in ft.
D = external diameter in in.
p = collapsing pressure in lb. per sq. in.

whence

$$p = \frac{806{,}300 \times 0.5^{2.19}}{\frac{94}{12} \times 29} = 777 \text{ lb. per sq. in.}$$

Allowing a factor of safety of 5 (see Progress Report of Boiler Code Committee, A.S.M.E.) gives 155.4 lb. per sq. in.

Taking 63.3 per cent of this to allow for a single-riveted lap joint makes the value of working pressure for purpose of comparison with the A.S.M.E. result to be 98.5 lb. per sq. in., or practically the same as the value given by the A.S.M.E. formula.

Modified Fairbairn Rule. The working pressure of a tube subjected to external pressure will obviously not be inversely proportional to the length indefinitely, as Fairbairn's rule would indicate. This has been partially counteracted by using a variable factor of safety, $\sqrt{(300 \div L)}$, where L is length in feet.

For the concrete case under discussion this gives a working pressure equal to

$$\sqrt{\frac{777}{\frac{300 \times 12}{94}}} = 125.8 \text{ lb. per sq. in.}$$

Making allowance for the lap joint gives

$125.8 \times 0.633 = 79.8$ lb. per sq. in., or 80.0 per cent of the value given by the A.S.M.E. formula.

Bureau Veritas Rule. This formula makes a distinction between the case where the flue is truly circular (i.e., butt joints or lapped and bevelled), and where the flue is not circular.

$$P = \frac{Ct^2}{DL}$$

where t = thickness of plate in in.

[1] For derivation, see Jour. Am. Soc. Nav. Engrs., August, 1916, p. 729 *et eq.*

D = outside diameter in in.
P = working pressure in lb. per sq. in. above atmosphere
L = length of furnace in ft., or length between rings
C = 70,000 when furnace is truly circular and the longitudinal seams are welded, butted, or lapped and bevelled, and double-riveted in last-named case
C = 60,000 when the furnace is not truly circular, or when the longitudinal seams are simply lapped

The above constants are for iron of fair quality. Multiply constants by 1.2 for mild steel.

For the concrete case under discussion this gives

$$P = \frac{60{,}000 \times 1.2 \times 0.5^2}{\frac{29 \times 94}{12}} = 79.3 \text{ lb. per sq. in.,}$$

or 79.47 per cent of the value given by the A.S.M.E. formula.

The above formula gives a much stronger design for the truly circular case than it does for the not truly circular case.

Hutton's Rule. This does not allow for a joint.

$$p = \frac{Ct^2}{dL}$$

where L = length in in.
d = outside diameter in in.
t = thickness in thirty-seconds of an inch
C = 660 for steel
p = collapsing pressure in lb. per sq. in.

For the concrete case under discussion this gives

$$p = \frac{660 \times 16^2}{29 \times 94} = 602 \text{ lb. per sq. in.}$$

Allowing a factor of safety of 5 and reducing to allow for single-riveted lap joint gives

$$\frac{0.633 \times 602}{5} = 76.1 \text{ lb. per sq. in., or 76.4 per cent of}$$

the value given by the A.S.M.E. formula.

German Government Rule. Thickness $= K \times P \times L \times D + 0.2$ cm.

where P = working pressure in kg. per sq. cm.
L = length between stiffeners in cm.
D = external diameter of furnace in cm.
K = 0.0035 when the longitudinal joints are lapped only.

For the concrete case under discussion this gives

$$2.54 \times 0.5 = 0.0035 \frac{P \times 0.4536}{2.54^2} \times 94 \times 2.54 \times 29 \times 2.54 + 0.2$$

$$P = \frac{(1.27 - 0.2)^2}{0.0035^2} \times \frac{1}{0.4536 \times 94 \times 29}$$

= 75.6 lb. per sq. in., or 75.7 per cent of the value given by the A.S.M.E. formula.

Lloyd's Rule. This does not allow for joint.

$$P = \frac{89{,}600t^2}{LD}$$

where P = working pressure in lb. per sq. in.
t = thickness of plate in in.
L = length of furnace in ft.
D = outside diameter of furnace in in.

For the concrete case under discussion this gives

$$P = \frac{89{,}600 \times 0.5^2}{\frac{94}{12} \times 29} = 98.7 \text{ lb. per sq. in.}$$

Reducing this to the corresponding value for single-riveted lap joint gives $98.7 \times 0.633 = 62.4$ lb. per sq. in., or 62.5 per cent of the value given by the A.S.M.E. formula.

U. S. Statute Rule. This is the same as the Lloyd's rule.

Michael Longridge's Rule. Michael Longridge takes C in Hutton's formula as 540 instead of 660; this gives 540/660 of the value obtained by Hutton's formula, or $540/660 \times 76.2 = 62.4$ lb. per sq. in., or 62.5 per cent of the value given by the A.S.M.E. formula.

British Board of Trade Rule. This permits a double-riveted lap joint.

$$p = \frac{75{,}000t^2}{(L+1)D}$$

where p = working pressure in lb. per sq. in.
t = thickness in in.
L = length in ft.
D = external diameter in in.

For the concrete case under discussion this gives

$$p = \frac{75{,}000 \times 0.5^2}{\left(\frac{94}{12} + 1\right)29} = 73 \text{ lb. per sq. in.}$$

Reducing this to the corresponding value for a single-riveted lap joint gives

$$73 \times \frac{0.633}{0.776} = 59.6 \text{ lb. per sq. in.}$$

or 59.7 per cent of the value given by the A.S.M.E. formula.

The previous results are collected below to facilitate comparison:

	Working Pressure	Percentage
A.S.M.E. Boiler Code	99.8 lb. per sq. in.	100.0
Fairbairn	98.5 lb. per sq. in.	98.7
Fairbairn (modified)	79.8 lb. per sq. in.	80.0
Bureau Veritas	79.3 lb. per sq. in.	79.4
Hutton	76.1 lb. per sq. in.	76.4
German Government	75.6 lb. per sq. in.	75.7
Lloyd's	62.4 lb. per sq. in.	62.5
U. S. Statute	62.4 lb. per sq. in.	62.5
Michael Longridge	62.4 lb. per sq. in.	62.5
British Board of Trade	59.6 lb. per sq. in.	59.7

Besides showing that the A.S.M.E. Boiler Code formula gives working pressures far too high, these results reveal the danger of the A.S.M.E. rule by no means fully because customary efficiencies have been taken for lap joints, and it can be shown that these are far too high due to neglected eccentricity. In the light of a new analysis which the author has made[1] of the weakening factor of a longitudinal lap joint in a cylinder subjected to external pressure, these results are modified as below:

	Working Pressure	Percentage
A.S.M.E. Boiler Code	99.8 lb. per sq. in.	100.0
Fairbairn	42.8 lb. per sq. in.	42.9
Fairbairn (modified)	34.7 lb. per sq. in.	34.8
Bureau Veritas	79.3 lb. per sq. in.	79.5
Hutton	33.1 lb. per sq. in.	33.2
German Government	75.6 lb. per sq. in.	75.8
Lloyd's	27.2 lb. per sq. in.	27.3
U. S. Statute	27.2 lb. per sq. in.	27.3
Michael Longridge	27.2 lb. per sq. in.	27.3
British Board of Trade	61.6 lb. per sq. in.	61.7

[1] Strength of Boiler Furnaces, Jour. Am. Soc. Nav. Engrs., August, 1916, p. 729.

These results, though arranged in the same sequence as before, are no longer in the order of descending magnitude. The reason is simply that those rules which permitted lap joints suffered no reduction, but those rules which did not permit a lap joint had to have their results diminished according to the new lower efficiency of a lap joint.

The writer is of the opinion that all existing rules permitting the use of lap joints do not make the necessary allowance for its weakness in comparison with solid plate or butt joints.

If the joint be formed as in Fig. 1, then it is possible to maintain true circularity, which eliminates all eccentricity of action. The strength will now be determined by the efficiency of the joint proper.

The value of the joint efficiency is a much more complex problem—in fact, a rigorous solution is not possible; it would, however, be much higher than the efficiency of the plate is under eccentric loading.

The most significant feature in the use of longitudinal lap joints for cylinders subjected to external pressure, is that, should the stress reach the elastic limit and deformation ensue, the *eccentricity of action is increased* and collapse is inevitable. In cylinders subjected to internal pressure, on the other hand, deformation decreases eccentricity and restores satisfactory conditions.

Considering that the use of longitudinal lap joints is rapidly diminishing in good practice for internal pressure, is it not desirable to prohibit absolutely their use for external pressure; or, what would serve equally well, cut down the acknowledged efficiency to its true value? If this were done, the use of a lap joint would entail such an abnormally thick plate to withstand a given pressure that considerations of economy would probably prohibit it.

JOHN AIREY.

Ann Arbor, Mich.

RELATION OF ENGINEERING SOCIETIES TO LEGISLATION AND PUBLIC AFFAIRS

TO THE EDITOR:

In the August issue of The Journal, page 642, Mr. Henry Hess stated in a very convincing manner his views regarding the proper attitude of engineers and their societies with reference to enactment of laws upon subjects concerning which engineers are practically the only well-informed persons. He stated that "in so restricting themselves they have actually broadened and deepened their influence on actual legislation. They have not sought nor do they seek to influence legislation, and in so refraining they have actually gained a deep and beneficial influence in and for the community."

This is a very important conclusion, and one to which engineers should give careful thought—the more so as it has a curiously familiar sound to those who have been listening to the arguments for and against universal suffrage. It is urged that certain classes of people will have a broader and deeper influence if they are not permitted to exercise suffrage. A similar argument appears to be advanced in the assertion that the national engineering societies, and presumably other engineering bodies, should not participate in public affairs.

Further on Mr. Hess stated that in one particular case many engineers "are now agreed that what they hoped for in the interest of the public and community actually came about much sooner and more readily as a result of their confining themselves to their special domain." The question thus arises as to "*whose* is the domain?" To whom belong the right and duty to draft new laws and to see that these are enacted? It is apparently assumed that the engineering organizations are not the proper persons to enter into legislative activity; but obviously some one must do this, and, however distasteful the duty to the highly trained scientific and professional man, he cannot safely neglect this duty, nor properly delegate it to some other class of citizens.

Possibly the answer may be that the duties of citizenship, so far as they pertain to drafting and enacting suitable laws, should be left to the lawyers. This is too often done, as shown by a study of law-making bodies—the great body is composed of lawyers, while engineers are notable by their absence. Is this the best condition, and are engineers to be commended because they and their organizations have abstained from public affairs? The training of a lawyer, while excellent in construing laws as they now exist, is not always conducive to a constructive attitude of mind. The lawyer is more impressed with the importance of existing precedents than of existing needs. However this may be, engineers should consider carefully whether they even tacitly admit that as a body they should refrain from the duties of citizenship and delegate to others the direct interest in making proper laws on subjects in which they are best informed.

As a matter of fact, those who have had much experience in state and national legislation appreciate that a good law, no matter how well drawn or greatly needed, has little hope of passage unless somewhere behind it is an effective man or body of men working intelligently in season and out of season for it. This activity may not be apparent from the surface, but it can always be found. Moreover, a matter which affects the entire community will rarely be enacted in a law suitable for the entire community unless there is a well-worked-out effort of this kind. The fact that the laws referred to have been enacted is undoubtedly due to conditions which may not be obvious and to the fruition of plans not made evident to the public.

The question is whether the engineer, and especially his organization, shall come out definitely and clearly for certain laws regarded as important, or whether he shall assume a more dignified attitude of agreeing upon certain principles and then decline to participate in the enactment of these principles into law. Shall his organization be indifferent to the means by which the desired end is to be accomplished, refraining from an outward or definite interest in the matter, knowing full well that some other class of citizens must exert themselves actively and continuously in order to secure the passage of these laws?

Or, to put it in another way, is there not really an attitude of complacent self-deception in the assumption that the engineering societies, by restricting their activities, are actually broadening and deepening their influence? Can any class of citizens in this country properly abstain from legislative activities and retain the respect of the community? These are points on which, as stated by Mr. Hess, representative opinions should be obtained for the guidance of engineering organizations in any future question concerning legislative and public affairs. My own feeling is that any association of independent citizens, especially those educated largely at public expense, as are most engineers, will inevitably be ignored, or even treated with contempt, by the great body of the public if it takes the position of refraining from actively performing its duties in legislation, particularly in those matters in which its members are best informed.

F. H. NEWELL.

Urbana, Ill.

Society Affairs

Engineering Survey

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THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

ABRIDGED LIST OF OFFICERS AND COMMITTEES

OFFICERS AND COUNCIL, 1916

President

D. S. Jacobus

Past-Presidents

Members of the Council for 1916

Jesse M. Smith
Alex. C. Humphreys
W. F. M. Goss
James Hartness
John A. Brashear

Vice-Presidents

Terms expire December 1916

Henry Hess
George W. Dickie
James E. Sague

Terms expire December 1917

Wm. B. Jackson
J. Sellers Bancroft
Julian Kennedy

Managers

Terms expire December 1916

Arthur M. Greene, Jr.
John Hunter
Elliott H. Whitlock

Terms expire December 1917

Charles T. Main
Spencer Miller
Max Toltz

Terms expire December 1918

John H. Barr
H. de B. Parsons
John A. Stevens

Chairman of Finance Committee

Robert M. Dixon

Treasurer

William H. Wiley

Honorary Secretary

Frederick R. Hutton

Secretary

Calvin W. Rice

Executive Committee of the Council

D. S. Jacobus, *Chairman*
John H. Barr
Arthur M. Greene, Jr.
Henry Hess
Spencer Miller
James E. Sague

COMMITTEES, ETC.

STANDING COMMITTEES

Chairmen

Finance, Robert M. Dixon
Meetings, H. L. Gantt
Publication, Irving E. Moultrop
Membership, Henry C. Meyer, Jr.
Library, John W. Lieb
House, William N. Dickinson
Research, R. J. S. Pigott
Public Relations (not appointed)
Constitution and By-Laws, Jesse M. Smith
Standardization, Henry Hess

SOCIETY REPRESENTATION

American Association Advancement of Science
American Society for Testing Materials, Modification Briggs Standard for Pipe Threads
Classification of Technical Literature
Conference Committee on Electrical Engineering Standards
Conference Committee of National Engineering Societies
Conference Committee to Determine Cost of Electric Power
Conservation
Engineer Reserve Corps
Engineering Foundation
Expert Testimony Committee
John Fritz Medal, Board of Award
Joseph A. Holmes Memorial
Naval Consulting Board of the United States
Standardization of Pipe and Pipe Fittings for Fire Protection
Trustees United Engineering Society

SPECIAL COMMITTEES

Chairmen

Administration, Robert M. Dixon
Am. Soc. M. E. Junior Prizes, Robert H. Fernald
Am. Soc. M. E. Student Prizes, Frederick R. Hutton
Boiler Code Committee, John A. Stevens
Engineering Education
Filter Standardization, George W. Fuller
Increase of Membership, Irving E. Moultrop
Metric System, L. D. Burlingame
National Museum
Nominating Committee, Walter B. Snow
Patent Laws, Edward Weston
Pipe Threads International Standard, Edwin M. Herr
Power Tests, Geo. H. Barrus
Refrigeration, D. S. Jacobus
Research Committee, R. J. S. Pigott
- Sub-Committee on Bearing Metals, C. H. Bierbaum
- Sub-Committee on Fuel Oil, Raymond H. Danforth
- Sub-Committee on Lubrication, Albert Kingsbury
- Sub-Committee on Machine Tools, Leon P. Alford
- Sub-Committee on Safety Valves
- Sub-Committee on Steam-Flow Meters, R. J. S. Pigott
- Sub-Committee on Worm Gearing, Fred A. Halsey

Sections, Elliott H. Whitlock
Standard Flanges and Pipe Fittings, Henry G. Stott
Standards for Graphic Presentation, Willard C. Brinton
Student Branches, Frederick R. Hutton
Tellers of Election, Robert H. Kirk
Tolerances in Screw Thread Fits, L. D. Burlingame

SECTIONS COMMITTEES

Chairmen and Secretaries

Atlanta, Earl F. Scott, Park A. Dallis
Birmingham, Roy E. Brakeman, Paul Wright
Boston, A. L. Williston, (Secretary not appointed)
Buffalo, John Younger, (Secretary not appointed)
Chicago, Joseph Harrington, R. E. Thayer
Cincinnati, F. A. Geier, John T. Faig
Detroit (not appointed)
Los Angeles, W. A. E. Noble, Ford W. Harris
Milwaukee, Edward Hutchens, F. H. Dorner
Minnesota, J. V. Martenis, D. M. Forfar
New Haven, H. B. Sargent, E. H. Lockwood
New Orleans, W. B. Gregory, H. L. Hutson
New York, H. R. Cobleigh, A. D. Blake
Philadelphia, Emmet B. Carter, Wm. R. Jones
St. Louis, H. R. Setz, L. A. Day
San Francisco, Frederick W. Gay, C. F. Braun
Worcester, Paul B. Morgan, Edgar H. Reed

A complete list of the officers and committees of the Society will be found in the Year Book for 1916, and in the July, 1916, issue of The Journal.

SOCIETY AFFAIRS

A Record of the Current Activities of the Society, its Members, Council, Committees, Sections and Student Branches; and an Account of Professional Affairs of Interest to the Membership

SECRETARY'S CHAT WITH THE MEMBERS

THIS month opens the season of Society activities under conditions which have never before been paralleled in our history. Events which will make the year 1916 a memorable one to engineers, thereby place each individual member of the Society under obligations, and make it encumbent upon him to help maintain the new position which the engineer, in distinction from other citizens, now occupies.

On a letter ballot from practically half its entire membership, the American Society of Civil Engineers has voted seven to one to make their headquarters in the Engineering Societies Building, and join the Founder Societies in the ownership and administration of the property of the United Engineering Society and the joint administration of the Library. This association, long hoped for by all who have the interests of the engineering profession at heart, will be of great advantage to the profession in general, will widen greatly its influence and enhance its standing. At the same time, and reciprocally, this association of the principal national engineering societies sets the example for similar coöperation of their sections and individual members, and puts upon the latter the obligation of contributing their share to the team work being done by the officers of the national societies. Each individual member of our Society should do his best this winter to foster and actively develop the broad-minded spirit behind the relations of the Society with all the national engineering societies, so that the coöperation for which we have all been striving will reach its highest degree.

National recognition was accorded the engineering profession and the chemists in the invitation extended to them by the President of the United States to conduct the industrial census. The census was made with the coöperation of the industries, to the extent that from 75 to 80 per cent of firms doing business annually in excess of one hundred thousand dollars have responded to the census request of the engineers' representatives, and the work will be completed this month. In their dealings with manufacturers, engineers must in future recognize this spirit of coöperation.

In the passage by Congress of two bills directly and permanently establishing the engineering profession as an arm of the Government, public recognition of the engineer is an accomplished fact. The features concerning engineers in these bills were initiated by engineers in their capacity as citizens confident of ability to render greater service. We asked for recognition and we received it; it remains for us to show that this recognition was justified. The two movements represented in these bills are:

Through the initiative of a joint committee, of which in our Society Major W. H. Wiley, Treasurer Am.Soc.M.E., is chairman, in coöperation with similar committees of the Civil, Mining, Electrical and Consulting Engineers, a Reserve Corps of Civilian Engineers, comparable to the reserve corps of physicians and surgeons, has been established, and General Order No. 32, providing for the enrolment of all civilian engineers of the United States in an auxiliary corps to the Army in case of war, has just been issued by the Chief of Engineers of the Army. This action opens up to engineers another opportunity for service on an honor roll subject to the call of the President of the United States, and the theory is that in time of stress each engineer will be assigned to that duty which he can best perform, supposedly a continuation of the work he performs in civil life.

The second accomplishment of the year is the establishment of the National Council of Safety. This is to consist of five Cabinet officers, with an advisory council of seven civilians, the latter to be chosen, one each, to represent labor, industry, finance, transportation, physics and chemistry, and commerce. It behooves our members to see that engineers are represented on this important council. The qualifications of those who are to compose the advisory council are stated as "special knowledge of some industry, public utility or the development of some natural resource. The members of the advisory commission shall serve without compensation, but shall be allowed actual expenses of travel and subsistence."

It is proposed that the existing associate members of the Naval Consulting Board, now our directors of state canvasses of the industrial census, together with the examiners chosen from our nominees appointed by the War Department for the Engineers' Reserve Corps, will form the nucleus of the permanent State Councils of Safety.

Speaking of the recognition of the engineer by the Government, it might be mentioned that the Secretary recently had the honor of a call from the Secretary of the Navy. This is apparently the first time in the history of the engineering societies that an executive officer of the Government has visited us. In wishing Mr. Daniels good-by, the Secretary expressed the hope that we might have a call from the President of the United States, in the same manner as in France, to discuss important public engineering works.

A meeting of the Joint Conference Committee of the National Academy of Sciences and the National Engineering Societies took place on September 19, and organized with Mr. J. J. Carty, Past President of the A. I. E. E., as permanent chairman and Calvin W. Rice as permanent secretary. The discussion was along broad lines to develop ways in which the Academy and the engineering societies may develop closer relations. The Academy has already created a division of engineering, and this year will commence the election of engineers to its membership.

A Nitrate Committee of the National Academy is just now reporting on a Government Nitrate Plant, for which Congress has appropriated $20,000,000, and in this work the engineers are coöperating.

The National Research Council, appointed at the request of the President of the United States by Dr. W. H. Welch, president of the National Academy, is composed of members of the National Academy and of the national engineering societies. Their

immediate function is to coördinate the research facilities of the Government, the educational institutions and commercial and private laboratories.

At the meeting, on September 14, of the Engineering Foundation, Dr. F. R. Hutton, the acting secretary, resigned, and Dr. Cary T. Hutchinson was chosen secretary. One of the pieces of work to be done by the Foundation is that of the Research Council.

The above instances are signs of the growing appreciation of the strength of coöperation, to the spirit of which, we reiterate in closing, it is part of the duty of every member of the Society to contribute.

During the present month either the President or the Secretary expects to be with the members at their meetings in Meriden, Conn.; Buffalo, Erie, Indianapolis, and other places, bringing the greetings of our Council and receiving the views of the members as to the ways in which the Society may advance.

CALVIN W. RICE,
Secretary.

PLAN OF ACTIVITIES FOR THE SEASON 1916-17

AN important function of The Journal is to inform members of the Society regularly what its Officers and Committees, its Sections and Student Branches, are engaged in and planning to do, and what relations the Society is maintaining with other organizations and with the mechanical engineering profession generally. The aim is to maintain the personal interest of each member in the Society's government and actions.

The Council is about to resume activities, and its next regular meeting will be held on October 13. At this meeting important matters will be brought up for consideration, including the budget for the fiscal year upon which we enter on the first of this month.

Annual Reports have been requested from all Standing and Special Committees, and are now coming in. These will be presented to the Council and embodied in its Annual Report to be made at the Annual Meeting in December. The reports of the Standing Committees will be published in The Journal in due course, and will indicate what work has been accomplished by the committees this year, as well as what work is contemplated.

An outline of the proposed activities for the season of the several Sections and Student Branches as reported by their officers is given below.

ATLANTA SECTION

Mr. Earl F. Scott, Chairman, reports that the Affiliated Technical Societies of Atlanta will hold four meetings during the year. Each of the national societies represented in this affiliation, including our Society, will be allotted one meeting. At each meeting the particular organization in charge will contribute the paper of the evening, and the other societies will participate as guests. Our Section will have charge of the meeting in July, 1917.

If the Section is fortunate in securing a visit from any prominent member of the Society, it will call a special meeting to entertain him and will invite other engineers to participate.

BIRMINGHAM SECTION

The Birmingham Section expects to have no less than ten meetings during this, its second season. At least seven of these meetings will be devoted to papers or illustrated lectures. The other meetings will be inspection trips and possibly one joint meeting with engineers from the membership of the other national engineering societies.

The chairman, R. E. Brakeman, has taken the initial steps towards interesting the engineering faculties of the state colleges, and expects to have very interesting and valuable coöperation from them. He has in fact already received assurances of their willingness to coöperate.

The Section held a meeting on September 16, which consisted of an inspection trip through the plants of The Continental Gin Company, The Payne and Joubert Company and the Hardis-Tynes Manufacturing Company.

BUFFALO SECTION

The Buffalo Section coöperates with the Engineering Society of Buffalo. John Younger, Chairman of the Section and president of the local society, furnishes the following program of meetings of the society:

October 18, 1916. Dr. D. S. Jacobus, President of the Society, on Relationships of the National Societies to the Local Societies.

November 1, 1916. Frank B. Gilbreth, Mem. Am. Soc. M. E., on Motion Study.

November 15, 1916. Mr. Russell, of the Burgess Aeroplane Company, on an aeroplane topic.

November 29, 1916. C. H. Bierbaum, Mem.Am.Soc. M.E., on Recent Research Work on Graphite.

December 13, 1916. An automobile topic.

January 3, 1917. Socal meeting.

January 17, 1917. Professor Spofford, of the Massachusetts Institute of Technology, on Highway Bridge Floors.

January 31, 1917. W. M. Corse, on Non-Ferrous Alloys.

February 14, 1917. An electrical engineering subject.

February 28, 1917. C. F. Kettering, Mem. Am. Soc. M. E., on Pure Science Applied to Engineering.

March 14, 1917. Mr. Zimmerschied, on Standardization.

April, 1917. Meeting will be devoted to discussion of Educational Systems and Apprenticeship Systems.

May 1, 1917. Business meeting.

CHICAGO SECTION

The Chicago Section has made plans for four meetings, with papers tentatively as below. The Section is making it its endeavor to secure the very highest class of speakers. It has the possibility of bringing out three or four hundred engineers of standing, and according to Joseph Harrington, chairman, the Section is fully alive to this fact.

November 17, 1916. Paper on either Industrial or Naval Preparedness. President Jacobus has been invited to attend this meeting.

January 19, 1917. Garbage Disposal in the City of Chicago.

March 16, 1917. Internal Combustion Engines under 50 H. P.

May 18, 1917. The Proper Preparation of the Young Engineer for Engineering Work.

CINCINNATI SECTION

The fact that the Spring Meeting, 1917, is to be held in Cincinnati is influencing the Section's activities there. The following recent communication from Prof. John T. Faig, Secretary of the Section demonstrates this:

"Dominating all of the activities of this Section for the season of 1916-1917 is the fact that the Spring Meeting for 1917 will be held in Cincinnati next May. Already tentative plans have been made regarding the visits to some of the most interesting plants and factories in this vicinity.

"Naturally there are to be found in this vicinity a number of large plants for the building of power machinery, which are the successors of those established by the river traffic. Strangely enough, however, the greatest expansion in the building of machinery has been along an entirely different line, that of machine tools. This is a comparatively recent development, extending over the last thirty-five years, and is the result of the foresight, perseverance and business ability of a group of men who are still living. During that short space of time they have built up factories whose products are known all over the world. Fifteen thousand men are employed in this field, and the annual output of the factories in which they work runs into many millions of dollars.

"It will be a great pleasure to members of this Section to show to fellow-members from elsewhere the results of Cincinnati's effort to do her share in the general industrial progress of the country.

"The tentative schedule of papers for the coming year includes several on steam and gas power, several on machine tool development and design and several on administration. It is hoped that the high standard set during the past year will be maintained. As stated before, however, the main business of this Section for the coming season is the organization of a record-breaking Spring Meeting for next May."

LOS ANGELES SECTION

Four technical sessions will be held in October, January, March and June respectively. The exact dates of these meetings are not yet determined.

The weekly luncheon meeting will be held every Thursday as last year. The members have responded ably and willingly at these luncheon meetings and the subjects discussed have been principally in the lines of local work in which the members are engaged.

This year the Section hopes to see further progress in its work in connection with bringing together into closer relationship the several engineering organizations of the city.

MINNESOTA SECTION

Professor Martenis, Chairman, writes that the Section has made elaborate plans for the forthcoming winter. Here, too, the activities proposed are best expressed in the Professor's own words:

"The Minnesota Section of the Am.Soc.M.E. will inaugurate a season of great activity at its first meeting to be held at the Main Engineering Building of the University of Minnesota on Thursday evening, September 14.

"Past experience seems to demonstrate the advisability of restricting the presentation of more than one good technical paper at each meeting. When more than one paper is presented, there is very little time left for discussion, and it is this part of the work that should be encouraged.

"It is proposed to widen the scope of papers to be presented, so that we may arouse a greater interest from those who are engaged in lines not heretofore discussed. For instance, we will have a paper on modern locomotive practice to attract our members and also prospective members who are interested and engaged in this line of work and who would not otherwise attend. We hope to develop the 'come to meetings' habit.

"A live social affair will come in January or February, and possibly a spring excursion in May.

"Realizing the importance of building up our membership, a large committee has been appointed to interest the many engineers in Minnesota who are qualified to join the Society and who would add materially to the effectiveness of the work of the Section.

"A plan must be worked out which will bring the members scattered about the State into closer working contact with the Section.

"The Minnesota Section will continue to coöperate with other engineers in holding occasional joint meetings.

"The existence and activities of the Section will become better known through the medium of the press, and it is proposed to appoint a committee for this purpose.

"The opportunities available for employment through the columns of The Journal of the Society will receive more consideration.

"The coming year is a most promising one, and we wish to make the greatest use of it for our Society and its members."

NEW ORLEANS SECTION

This newly organized Section has plans for the coming year which, it is hoped, will prove of interest and benefit to the local membership.

The dates for the meetings, with the topics for discussion, have been decided as follows:

October 2, 1916. Discussion of paper on The Design and Test of a Large Reclamation Pumping Plant, published in The Journal.

January 15, 1917. Oil Burning.

April 2, 1917. Preparedness.

July 2, 1917. The A.S.M.E. Boiler Code.

The meetings will be held in the rooms of the Louisiana Engineering Society. The first meeting will be a joint meeting with the Louisiana Association of Members of the American Society of Civil Engineers. The paper to be discussed is of much interest to both mechanical and civil engineers in this section of the country.

It is hoped that the President or Secretary of the Society will be able to attend one of the meetings during the year.

NEW YORK SECTION

The active season will be opened with an informal smoker on September 29, at which time tentative plans for the coming year, also for the Annual Meeting of the Society in December, will be discussed.

The October meeting of the Section will be held on the 10th. Dr. Charles L. Reese, of the E. I. du Pont de Nemours Powder Company, will speak on Explosives, giving special attention to the use of explosives for industrial purposes.

Monthly meetings are planned, as last year. These will again be preceded by the "get-together" informal dinners.

With the exception of the President's reception, all excursions and entertainment features of the Annual Meeting are placed in charge of the New York Section Committee.

The Section has decided to provide a mid-day luncheon in the Engineering Societies Building on Wednesday and Thursday of the week of the Annual Meeting; the charge will be nominal. Details of the excursions and entertainments are now being worked out by committees.

PHILADELPHIA SECTION

The Philadelphia Section is particularly fortunate in its affiliation with the Engineer's Club of Philadelphia, which is furnishing the Section with headquarters and keeping it in touch with all the engineering activities in the district. The Engineer's Club has been exceptionally liberal in its treatment of the affiliated societies, and has developed a feeling of good fellowship among the members of those societies.

It is proposed to hold eight meetings of the Section during the season. The dates as yet determined are:

October 24, 1916. The Development of Our Fleet and Naval Stations, by Prof. William L. Cathcart.

November 28, 1916. Aeroplane Engines, by Mr. Huntington of the Aero Club.

January 23, 1917. Coke Ovens and their By-Products, by Mr. Ramsberg, Vice-President of the Koppers Company.

February 27, 1917. A meeting on the textile industry.

March 27, 1917. District Heating, by Walter J. Kline, of the American District Steam Company.

April 24, 1917. Entertainment for the President of the Am.Soc.M.E. by the Philadelphia Section.

May 22, 1917. Engineering of Men, by Willard Behan.

Three of the meetings will be in charge of Emmett B. Carter, Chairman of the Section, one in charge of J. A. Steinmetz, one in charge of C. L. Bruff and one in charge of Prof. R. H. Fernald.

PROVIDENCE ENGINEERING SOCIETY

The Providence Engineering Society, affiliated with our Society, has this year leased the second floor of one of the Rhode Island School of Design buildings, and Henry D. Sharpe, Mem.Am.Soc.M.E., has made a generous gift to the society of $1,500 for furniture. A "house warming" will be held on October 11.

The Society plans one general engineering meeting a month and perhaps three Section meetings a month.

This summer the Society has increased its membership by 300.

ST. LOUIS SECTION

The St. Louis Section will endeavor to cultivate more than ever the spirit of sociability, as well as to awaken a more pronounced feeling of solidarity. The Section considers the latter particularly desirable today in view of the important changes which are taking place in the structure of our social and industrial institutions.

H. R. Setz, Chairman, reports that the tentative program for the season's activities has been drawn up and is now being confirmed.

WORCESTER SECTION

The Worcester Section enters upon its second year with the assurance of a successful season. Paul B. Morgan, Chairman, announces that the Section will this year take full advantage

of the circumstance that it is located in the center of an inventive field. Mr. Morgan writes:

"That portion of Central Massachusetts, known as Worcester County, has in the past been famous for men who have made inventions which have fairly revolutionized methods in the branches of industry affected. At the present time there is no cessation of the exercise of this same inventive faculty here. It has been planned by the Local Section Committee to center its activities for the present season about this fact.

"The first meeting will be held about the middle of November, when it is hoped that as one feature a paper will be presented outlining what has been accomplished here in the past. This meeting will be followed by two others, one in February and another in April, at which will be considered important mechanical developments of the present day which are being worked out here by men, most of whom are members of our Society. Many of us have but a fragmentary conception of the magnitude of these developments and it is hoped that we shall be able to bring this matter before our Section members. An exposition of this sort will doubtless stimulate all and particularly our younger members, and increase the interest in the Society among outsiders.

"We look forward confidently to a considerable increase in membership during the coming season."

At the time of going to press, the final programmes of activities of the Sections at Boston, Detroit, San Francisco and New Haven had not been received. It is planned to publish these next month, however.

STUDENT BRANCHES

The *Kansas State Agricultural College Student Branch* will hold a weekly meeting throughout the college year in order to enable the mechanical engineering students to become familiar with the various phases of the profession and with the ideals and ethics of master engineers. Two of the meetings each month will be devoted to the discussion of papers appearing in The Journal and to the presentations of new papers by student members of the Society. The other two meetings will be devoted to talks by members of the engineering faculty and outside engineers.

At the *Syracuse University Student Branch*, the following will be undertaken: (1) Presentation of technical papers by members of the branch and discussion; (2) lectures by engineers, possibly men sent by the Society; (3) discussion of the broader engineering subjects dealing with the engineer and the public; (4) coöperation with either the college or city Y. M. C. A. in educational work among the foreign industrial class, with a spirit of friendly interest in the men.

Throop College of Technology Student Branch will hold monthly meetings, some of them joint meetings with the student branch of the A. I. E. E. In addition excursions will be made to manufacturing plants in the vicinity of the college.

The general plan at the *University of Kansas Student Branch* this year will be to have meetings every Thursday evening. Three meetings each month will be in charge of the students and be given up to discussions of particular subjects; at the fourth meeting the discussions will be more general. The branch expects to hold an annual meeting in February or March, and needs a speaker with a message to the students to complete the program.

Stevens Institute of Technology Student Branch is going to devote all its energies to arranging for an interesting series of inspection trips and, if possible, a few lectures on engineering topics. It has also determined to interest more of the seniors in membership in the Society.

University of California Student Branch. It is proposed that at each of four meetings during the semester two students shall present papers upon such topics as they themselves shall select, there shall be a short talk or lecture by some member of the faculty, and discussion of the papers presented. For each of the other three meetings of the half year, it is proposed to invite some prominent member of the profession to deliver a lecture upon a practical subject of general interest, with the opportunity for discussion or questions.

The Student Branch at the *University of Nebraska* is looking forward to the coming year with pleasure. Even at this early date a spirit of fellowship exists, which promises to bring success to all society activities. Meetings will be held the first Tuesday of each month, at which time talks will be given by men with practical engineering experience. It is the aim of the branch to get every mechanical engineer, including freshmen, into the spirit of the work and to have them attend the meetings regularly. The first meeting, to be held on September 19, will be a get-together meeting and short talks will be given by the members concerning their summer's work; later the faculty will be introduced and short talks from them will be in order. It is intended to hold a smoker the second week of school and get every M. E. student interested in the Society and its affairs.

Although the schedule of the *University of Cincinnati Student Branch* has not yet been completed, it is planned to start work on September 25 with a membership campaign. During the year, papers on motor car engines, production work, the development of the machine tool industry in Cincinnati, and various other topics will be read before the branch. The discussion of the subjects will be general enough to interest all the members. A series of trips to new factories is being arranged. The Spring Meeting of the Am.Soc.M.E. will be held in Cincinnati in May and the local student members are planning to attend many of the sessions; invitations will be extended to the student branches in the vicinity to fraternize with the Society's branch during the meeting, and a smoker in honor of visiting members will be held at the University.

Leland Stanford Junior Student Branch will hold meetings of a professional or technical character every two weeks. At one-half of these meetings the students will assume full responsibility for the material to be presented, together with the discussion of it. For the remaining one-half it is expected that the material presented will be in the form of addresses or papers by engineers of San Francisco and vicinity.

There are at Stanford University five engineering societies composed of students specializing respectively in civil, mining, mechanical, electrical and chemical engineering; and it is the purpose during the year to foster and stimulate coöperative action among these societies with a view to holding a number of engineering assemblies. At least one joint social meeting with A. I. E. E. Student Branch is contemplated.

Virginia Polytechnic Institute Student Branch proposes to have a number of addresses by prominent men and to continue the practice of having papers by students themselves, which has been found very valuable. The administration of the institute has shown its appreciation of the work of the branch by offering a prize of a subscription to The Journal to the three best men in the year.

A meeting or excursion every two weeks is planned by the *Massachusetts Institute of Technology Student Branch*. The plan of having the students conduct the entire programme themselves, so successful last year, will be continued. Prominent engineers will be invited to address the meetings, and the excursions will be made to power houses or manufacturing establishments near Boston.

The *University of Illinois Student Branch* began the year with a business meeting on September 28, when plans for the coming season were discussed.

Seven or eight meetings are to be held during the first semester, and approximately the same number in the second. It is hoped at every one of these meetings to have presented, in the main by the student members themselves, at least one paper on a subject of an engineering nature.

The *Ohio State University Student Branch* will duplicate the practice of last year by having meetings every two or four weeks. At these meetings student members will either describe their observations or experiences in engineering work, read a paper giving the result of their inquiry and reading in the library, or read the text of a lecture furnished by the society, or addresses will be made to the branch by local or visiting engineers.

Copies of The Journal and other periodicals will be kept on file in the laboratory so that students may be encouraged to study their contents.

The above gives the plans of thirteen out of the forty Student Branches. The remaining branches are expecting to resume work during the present month, and we hope to be able to give reports of their prospects in the next issue of The Journal.

J. Sellers Bancroft and Henry Hess were guests of the Tenth Annual Convention of the Illuminating Engineering Society, held in Philadelphia, September 18 to 20.

THE THIRTY-SEVENTH ANNUAL MEETING

NEW YORK CITY, DECEMBER 5 TO 8

MEMBERS will soon be making their plans to attend the Annual Meeting, and to help them we give a few of the features of the meeting, in the hope that all will be persuaded that the convention will be well worth while.

To provide the mental stimulus, the Committee on Meetings, with its ten sub-committees, has been working for several months, and a glance at the papers they have secured will convince anyone that considerable benefit will be derived from attendance at the meeting.

Parallel with the professional sessions, the Entertainment Committee has been working assiduously to provide an ideal social programme, and will assure that all visitors will be made at home and have a good time.

A synopsis of the programme of the meeting is given below. In this synopsis titles and days on which events are to occur are given, for the benefit of members who may have to make special arrangements.

OPENING FEATURES

On Tuesday, December 5, headquarters will open at the Engineering Societies Building, and registration will be commenced. There will be a Council Meeting and a Conference of Sections.

In the evening the President of the Society, Dr. D. S. Jacobus, will deliver his presidential address on the subject of the Relation of Education to Engineering. Following the address there will be a reception by the Society to the President, President-Elect, ladies, members and guests.

On the morning of Wednesday, December 6, a business meeting will be held. At this the reports of the Council and Committees for the year will be presented, new officers elected, etc. Following the business meeting there will be a brief memorial meeting as a mark of respect to the memory of the late Dr. John Edson Sweet, Past-President and Honorary Member of the Society.

PROFESSIONAL FEATURES

An all-day Valuation Session will be held on Thursday, December 7. The Committee on Meetings has taken special pains to secure authoritative papers for this session, and a number of representative engineers will contribute valuable discussion. The titles of papers to be presented include Accurate Appraisals by Short Methods; Industrial Valuation Differs from Public Utility Valuation; Perpetual Inventory Value vs. Appraisal Value; Engineering Economics of Partial Construction; Amortization and Depreciation; Production Capacity as a Measure of Value of Industrial Property.

A Gas Power Session will be held on Thursday afternoon. The Sub-Committee on Gas Power has worked diligently to secure the success of this session and deserves special credit for its accomplishments. The titles of papers expected include Tar Forming Temperatures of Coals; Marine Diesel Engines; Results with Heavy Oil Engines; Experiences with the Humphrey Pump; Theory of Ignition in Internal Combustion Engines; Gas Tractors; Commercial Methods of Sampling and Analyzing Producer Gas, etc.

Two Machine Shop Sessions will be held, one on Wednesday afternoon and one on Thursday afternoon. The Sub-Committee on Machine Shop Practice has been fortunate in securing two leading authorities to present the subject of Standardization of Machine Tools; the chairman himself will discuss the Classification of Machine Shop Practice, and there will be miscellaneous papers.

A Textile Session will be held on Wednesday afternoon. This session is in charge of the Sub-Committee on Textiles, which announces three papers, including Relations of Importance between Moisture in the Air and Moisture in Materials, and Experiments to Determine the Relative Heat Transmission through Various Types of Sash.

A Railroad Session, the papers for which have been secured by the Sub-Committee on Railroads, will be held on Friday morning. The topics of papers include Pulverized Fuel for Locomotives, Clasp Brakes, and Electric Locomotives.

Papers not contributed by Sub-Committees, including this year a number of titles of sufficient diversity to insure interest for every one, and yet each one constituting an authoritative opinion on its special subject, will be presented at three Miscellaneous Sessions, planned for Wednesday morning, Wednesday afternoon and Friday morning. It is always a matter of difficulty to group such papers into sessions, but unfortunately the limitations imposed upon the Committee by the large number of papers offered, and the impossibility of devoting an entire session to the discussion of one paper only, render it necessary to group the papers as may seem best. Titles of these papers include The Proportioning of Surface Condensers; Small Steam Turbines; Graphic Methods of Power Plant Design; Ratio of Specific Heats and Coefficient of Viscosity of Natural Gas; Internal Combustion Engines, and The Impact Tube.

A session in charge of the Sub-Committee on Protection of Industrial Workers will be held on Wednesday morning.

On Friday morning there will be a session for the presentation of papers relating to steam boiler subjects; this session will be in charge of the Boiler Code Committee. On Friday afternoon there will be a public hearing on the revision of the Boiler Code.

Manuscripts of papers are being sent to the printer as soon as released by the Committee on Meetings, and it is anticipated that all the papers will be available in pamphlet form in advance of the meeting for distribution to members desiring to contribute discussion. Further, comprehensive abstracts will be published in The Journal before the meeting.

ENTERTAINMENT FEATURES

The reception on Tuesday evening will be followed by dancing and a collation. On account of the difficulty of handling this affair in the Society's rooms, due to the congestion from the increasingly greater number attending, the reception and dance will this year be held on the fifth floor of the Engineering Societies Building, as will also the Wednesday and Thursday evening functions. Luncheons are also to be served on the fifth floor between the forenoon and afternoon professional sessions on Wednesday and Thursday.

The success of last year's smoker has decided the repeating of this form of entertainment for Wednesday evening. A feature of the program will be a short talk by Frank B. Gilbreth, Mem.Am.Soc.M.E., who will recount his experiences in Germany during the European War.

On Thursday evening there will be an illustrated lecture by Dr. John A. Brashear on "The Science of the Beautiful in the Familiar Things of Everyday Life." Those who have listened to "Uncle John" before will look forward with the keenest anticipation to this address, in which it will be the Doctor's purpose to show by experimental physical demonstrations how much we miss in the path of everyday life in that which is beautiful all around us, and to induce, if possible, every engineer to have a hobby outside of his everyday calling.

Following this lecture, which will be given in the Auditorium of the Engineering Societies Building, there will be a reunion and informal dance, with light refreshments, on the fifth floor.

Other entertainment features include the usual conducted excursions to points of interest, the college reunions, which, by the way, are increasing in number each year, and a smoker as last year.

ELECTION OF OFFICERS

Before the end of this month, a ballot stating the names of candidates for the several offices falling vacant will be sent to each member entitled to vote. This ballot will be prepared from the report of the Nominating Committee, charged by President Jacobus with the duty of nominating candidates for the vacancies.

It will be recalled that the Nominating Committee was this year appointed by the President, and its members were chosen by the five groups of the different geographic sections of the Society, with the object of securing the greatest possible democracy. The committee consisted of Walter B. Snow, Chairman, representing the Boston, New Haven and Worcester Sections; H. M. Montgomery, representing the Chicago, Milwaukee and Minnesota Sections; E. H. Ohle, representing the Atlanta, Birmingham, St. Louis and Cincinnati Sections; J. T. Whittlesey, representing the San Francisco and Los Angeles Sections, and D. Robert Yarnall, representing the New York, Philadelphia and Buffalo Sections. The report from the Chairman follows:

TO THE SECRETARY:

Dear Sir: Acting for the Nominating Committee, which you advised upon February 24, 1916, of their appointment by the President, I have the honor to submit the following report.

As the result of several meetings at New Orleans in April, and subsequent personal interviews on the part of individual members, the following names of nominees for the various elective offices next falling vacant under the Constitution, together with the written consent of each nominee, are herewith presented:

For President, for one year:

IRA N. HOLLIS, Worcester, Mass.

For Vice-Presidents, for two years:

CHARLES H. BENJAMIN, Lafayette, Ind.
ARTHUR M. GREENE, JR., Troy, N. Y.
CHARLES T. PLUNKETT, Adams, Mass.

For Managers, for three years:

ROBERT H. FERNALD, Philadelphia, Pa.
WILLIAM B. GREGORY, New Orleans, La.
C. R. WEYMOUTH, Berkeley, Cal.

For Treasurer:

WILLIAM H. WILEY, New York, N. Y.

Respectfully submitted,
FOR THE COMMITTEE,
(*Signed*) WALTER B. SNOW, *Chairman.*

A brief account of the professional careers of each of the nominees is given below. Members are asked to read these accounts carefully, especially of candidates not known to them personally, so that when they receive their ballots they may vote intelligently.

IRA NELSON HOLLIS

Ira Nelson Hollis, president of Worcester Polytechnic Institute, was born in Mooresville, Md., in 1856. He received his early education in the public schools of Louisville, Ky., and in 1874 was appointed cadet engineer at the U. S. Naval Academy, from which he was graduated in 1878. Two years later he was commissioned assistant engineer in the United States Navy, and in 1888 passed assistant engineer. He resigned from the navy in 1893 to accept an appointment as professor of engineering at Harvard University, and in 1913 was called to his present position.

During the fifteen years after graduation from the Naval Academy, he served in various positions connected with the design, inspection and operation of marine machinery, and was chief engineer of two ships.

Dr. Hollis received the honorary degree of Master of Arts from Harvard University in 1899, the degree of L.H.D. from Union College in the same year, and the degree of Doctor of Science from the University of Pittsburgh in 1912.

He was elected to membership in The American Society of Mechanical Engineers in 1884, and was Vice-President of the Society from 1911 to 1913. He is at present serving on the Committee on Constitution and By-Laws.

He is a Fellow of the American Academy of Arts and Sciences, and a member of the Society of United States Naval Engineers, the American Society of Naval Architects and Marine Engineers, the Boston Society of Civil Engineers, and the Society for the Promotion of Engineering Education.

Dr. Hollis is the author of History of the Frigate *Constitution* (1900), and War College Lectures on Naval Ships (1912), as well as of a paper read before the Society in 1909, entitled Cast-Iron Fittings for Superheated Steam, and others dealing with naval, educational and engineering subjects.

CHARLES HENRY BENJAMIN

Charles Henry Benjamin, dean of the schools of engineering and director of engineering laboratories, Purdue University, was born at Patten, Me., in 1856. After serving an apprenticeship of three years with Benjamin & Allen, of Oakland, Cal., he matriculated at the University of Maine, from which he was graduated in 1881 with the degree of Mechanical Engineer. He was retained by this institution in the successive capacities of instructor and professor of mechanical engineering until 1886, when he resigned to become mechanical engineer for the McKay Machine Co., of Boston, Mass.

In 1889 Dr. Benjamin was appointed professor of mechanical engineering at Case School of Applied Science, where he remained until 1907, the year in which he became connected

with Purdue. The degree of Doctor of Engineering was conferred on him by Case School of Applied Science.

He was elected to membership in The American Society of Mechanical Engineers in 1892. He is also a member of the Engineers' Society of Cleveland, the Western Railway Club, the Master Car Builders' Association, and the Master Mechanics' Association.

He is the author of Modern American Machine Tools (1906), Machine Design (1906), The Steam Engine (1909), and of the following papers read before the Society: Electricity vs. Shafting in the Machine Shop (1897); Friction Horsepower in Factories (1897); Experiments on Cast Iron Cylinders (1898); Bursting of Small Cast Iron Flywheels (1899); Friction of Steam Packings (1900); Some Experiments on Ball Step-Bearings (1901); The Bursting of Small Cast Iron Flywheels (1902); Experiments on Spiral Springs (1902); The Bursting of Emery Wheels (1903); Smoke and Its Abatement (1905).

He has been a frequent contributor to technical journals, and his researches, have dealt with lubrication, locomotive headlights, and other topics not indicated in the foregoing list of publications.

ARTHUR MAURICE GREENE, JR.

Arthur Maurice Greene, Jr., professor of mechanical engineering at Rensselaer Polytechnic Institute, was born in Philadelphia, Pa., in 1872. He was educated at the University of Pennsylvania, receiving the degree of Bachelor of Science in 1893, and that of Mechanical Engineer a year later. He was instructor in mechanical drawing for one year at Drexel Institute, and then instructor in mechanical engineering at the University of Pennsylvania until 1902. From 1902 to 1907 he was professor of mechanical engineering at the University of Missouri (junior dean, 1906-1907), resigning therefrom in the latter year to assume his present position. He was assistant engineer of the Philadelphia Traction Company at different periods between 1893 and 1909, and mechanical engineer and chairman of a group jury of the National Export Exposition in 1899.

Professor Greene entered the Society as a junior in 1895, and was elected to full membership in 1903. He has been a Manager since 1913, and is at present serving on the Research and Boiler Code Committees, as well as Society Representative on the Constitutional Convention and on the Joint Conference Committee of the Society and the American Society for Testing Materials.

He is a Fellow of the American Association for the Advancement of Science, and a member of the Society for the Promotion of Engineering Education, and of The Franklin Institute.

He is the author of Pumping Machinery (1911), Elements of Heating and Ventilation (1912), and Heat Engineering (1915); also, at an earlier date, in collaboration with H. W. Spangler, of Elements of Steam Engineering. In 1907, he presented a paper before the Society entitled Entropy Lines of Superheated Steam.

CHARLES T. PLUNKETT

Charles T. Plunkett, cotton manufacturer, was born in Adams, Mass., in 1855, and was educated in the high school of that city. He has been identified with cotton manufacturing in Adams since 1877, and has given much study to the mechanical and hydraulic problems of mill work, resulting in improved mill construction and in new designs of water-wheel casings and draft tubes.

Mr. Plunkett was elected to membership in the Society in 1909. He was made a member of the Sub-Committee on Textiles in 1912, of which committee he has been chairman since 1913. He was president of the National Association of Cotton Manufacturers in 1908 and 1909, and is a member of engineers' clubs in New York and Boston.

He is president of the Berkshire Cotton Manufacturing Company, of Adams, and of the Industrial Mutual Insurance Company, of Boston; also a director of the Greylock National Bank, the Cotton-Woolen Mutual Fire Insurance Company, and the Rubber Mutual Fire Insurance Company.

ROBERT HEYWOOD FERNALD

Robert Heywood Fernald, professor of dynamical engineering at the University of Pennsylvania and consulting engineer of the U. S. Bureau of Mines, was born in Orono, Me., in 1871. After being graduated from the University of Maine in 1892, he spent one year as graduate student at the Massachusetts Institute of Technology, and then accepted appointment as instructor in mathematics and mechanical engineering at Case School of Applied Science. In 1896 he became assistant professor of mechanical engineering, leaving that institution in 1900 to take up graduate study at Columbia University. From 1902 to 1908 he was professor of mechanical engineering at Washington University, when he was appointed to the same chair at Case School of Applied Science. In 1912 he accepted the position he now holds. From 1902 to 1909 he was also engineer in charge of the technologic branch of the U. S. Geological Survey, and since 1912 he has been consulting engineer of the first division of the U. S. Bureau of Mines. In 1898 he received the degree of Mechanical Engineer from Case School of Applied Science, and in 1901 and 1902 the degrees of Master of Arts and Doctor of Philosophy, respectively, from Columbia University.

Doctor Fernald became a junior member of the Society in 1900, and was elected to full membership in 1903. He has served on many committees in the past, and at present is a member of the Committee on Meetings and the Special Committees on Am.Soc.M.E. Junior and Student Prizes. He is also chairman of the Philadelphia Section of the Society.

He is a Fellow of the American Association for the Advancement of Science, and a member of the Society for the Promotion of Engineering Education, the American Society for Testing Materials, The Franklin Institute, the Engineers' Club of Philadelphia, and the Philadelphia Chamber of Commerce. In 1912 he was president of the Cleveland Engineering Society.

He has been engaged almost continuously for fifteen years in research work in connection with the Bureau of Mines, and is the author of numerous monographs on fuels, producer gas for power purposes, gas-engine investigations, etc., in addition to the following papers presented before the Society: Method of Determining the Temperature of Exhaust Gases (1902); Working Details of a Gas Engine Test (1902); Results of the Preliminary Producer Gas Tests of the United States Geological Survey Coal Testing Plant at St. Louis (1906).

WILLIAM BENJAMIN GREGORY

William Benjamin Gregory, professor of experimental engineering at Tulane University, was born at Penn Yan, N. Y., in 1871. His education was received at Cornell University,

from which he was graduated in 1894 with the degree of Mechanical Engineer (M.M.E., 1908). From 1894 to 1897 he was instructor in drawing at Tulane University, from 1897 to 1902 assistant professor of experimental engineering, from 1902 to 1905 associate professor, and since that date full professor. His vacations have been largely spent in erecting sugar machinery and power plants and in drainage investigations. In addition to his educational activities he has served as consulting engineer for the Mississippi River Commission on tests of hydraulic dredges and accessory machinery.

Professor Gregory was elected to junior membership in the Society in 1895, and to full membership in 1903. He was a member of the Nominating Committee, and chairman of the Special Committee for the Spring Meeting of 1916.

He is a member of the American Society of Civil Engineers, the American Society for Testing Materials, the Louisiana Engineering Society (president, 1910), and the New Orleans Academy of Sciences (president, 1914).

His investigations have been largely along hydraulic lines, dealing with drainage, rice irrigation, the raising of large volumes of water through small lifts, and with the allied subjects dealt with in the following papers which he has presented before the Society: Tests of a Centrifugal Pump (1901); Pitot Tube (1904); Test of a Rotary Pump (1907); Some Pitot Tube Studies (1908); The Evolution of Low Lift Pumping Plants in the Gulf Coast Country (1916).

CLARENCE RAYMOND WEYMOUTH

Clarence Raymond Weymouth, mechanical engineer, was born at Oakland, Cal., in 1876. In 1898 he was graduated from the University of California, receiving the degree of Bachelor of Science. For the eight years prior to graduation he served apprenticeship periods in various shops during vacations. In 1899 he began work as draftsman for the firm of Chas. C. Moore & Company, of San Francisco, Cal.; in 1902 he became chief draftsman, and a little later inspector of work under construction and in charge of installation. In 1909 he was made chief engineer of the firm, which position he now holds.

Mr. Weymouth entered the Society as a junior in 1904, and was elected to full membership in 1907. In 1913-14 he served as a member of the Committee on International Engineering Congress, 1915, and also as member of the committee in charge of the San Francisco Section of the Society. He has given much attention during the course of his practice to the use of oil fuel, as the following papers presented by him before the Society attest: Fuel Economy Tests at a Large Oil Burning Electric Power Plant Having Steam Engine Prime Movers (1908); Unnecessary Losses of Firing Fuel Oil and an Automatic System for Their Elimination (1908); Dimensions of Boiler Chimneys for Crude Oil (1912).

WILLIAM H. WILEY

William H. Wiley was born July 10, 1842, in New York City, and received his A.B. degree from the College of the City of New York in 1861, and the degree of C. E. from Rensselaer Polytechnic Institute in 1866. He also studied as a special student at the Columbia School of Mines in 1868.

At the outbreak of the Civil War he joined the Seventh Regiment of New York Volunteers, and in 1862 was made first lieutenant. When the regiment was mustered out in 1864 he was given the title of Major U. S. V.

Since 1876 Major Wiley has been a publisher of scientific works. He served as a member of the 58th, 59th and 61st Congresses from New Jersey. In 1897 he was president of the International Jury of the Brussels Exposition, and was a member of the Superior Jury, Brussels. He was a commissioner from New Jersey at the St. Louis Exposition in 1904.

Major Wiley is the author of a book on Yosemite, Alaska, and Yellowstone, published in 1888, and has acted as New York Correspondent for London Engineering. He is a member of the American Society of Civil Engineers, the American Institute of Electrical Engineers, the American Institute of Mining Engineers, the American Association for the Advancement of Science, the National Geographic Society, the Order of Leopold, Belgium, and the Loyal Legion.

Major Wiley has been a member of the Society since its organization. He was appointed on the Finance Committee in 1882. While serving as Chairman of this Committee he was elected Treasurer of the Society, in 1884, and has been regularly nominated and elected for the period of thirty-two years which has since elapsed.

ROLL OF HONOR

THE Society is desirous of publishing lists of all members enlisted or contemplating enlistment in the National Guard, the Regular Army, the Naval Militia, the Navy, or in any other capacity in the services of the country. Every member who is, or who knows of any other member who is engaged in the service of the country is requested to notify the Secretary.

The first Roll of Honor was published in the August issue of The Journal, the second in the September issue, and the third, comprising further names received to date, appears below.

ADAMS, CARROLL E., Private, Battery A, Rhode Island National Guard

ALLISON, JOHN F., First Lieutenant, 3d Regiment, Penn Machine Gun Company, Fort Bliss, Tex.

ALLYN, ROBERT S., Major, 9th Coast Defense Command, C. A. C., National Guard, New York

BERGER, J. G., Aide, Naval Consulting Board, Mercer Co., N. J.

BRENNAN, JAMES, Captain and A.D.C., 7th Division, U. S. A.

BROOM, BENJ. A., Field Aide, Naval Consulting Board, Woodbury Co., Ia.

BUCKLER, ALBERT, Assistant Superintendent, U. S. Lighthouse Service

BURROUGHS, JOS. H., JR., First Class Private, Company B, Engineer Battalion, National Guard, Pennsylvania

BUSH, HAROLD M., Major, Ohio Battalion of Artillery, National Guard

CLUETT, SANFORD L., R. L. Signal Corps, National Guard, New York

COMSTOCK, CHARLES W., Second Lieutenant, Field Artillery, National Guard, Colorado

CRUIKSHANK, BARTON, Captain, R. L., First Cavalry, National Guard, New York

DAVIS, FRANCIS P., Second Lieutenant, Coast Artillery Corps, New York National Guard. Assigned to 33d Co., 8th C.D.C.

DEWOLF, ROGER D., Lieutenant, 7th Division, 3d Battalion, Naval Militia, New York

DOYLE, M. A., Second Lieutenant, Engineers, U. S. Coast Guard

DURAND, W. F., Member, National Advisory Committee on Aeronautics

EAGER, WILLIAM G., Sub-Chairman, Industrial Census, Naval Consulting Board, South Georgia. Member, American Legion

EHRMANN, JOHN P., Ordnance Department, Watervliet Arsenal

FITZGERALD, EDWARD T., Captain, 2d Battalion, Naval Militia, New York

FRY, ALFRED BROOKS, Captain, Naval Militia and Engineers' Reserve List, U. S. N.

FULLER, RAY W., Captain, Company A, Engineers, U. S. and Penna.

GUNBY, FRANK M., Captain, Artillery Engineer, C. A. C., Massachusetts National Guard

HALL, HARRIS F., Captain, Company M, 6th Infantry, Illinois National Guard

HUBBELL, LYMAN P., Captain, Quartermaster Corps, 74th New York Infantry, National Guard. On duty at Pharr, Texas

HUTCHISON, MILLER REESE, Member and Assistant to Chairman, Naval Consulting Board of the United States

INGHAM, HOWARD M., Corporal, 1st Motorcycle Battery of Englewood, N. J.
JOHNSTONE, EDWARD J., Lieutenant, Junior Grade, Naval Militia
KESSLER, ARMIN GEORGE, Lieutenant, Senior Grade, Naval Militia, Erie, Pa.
KILPATRICK, JOHN D., Major, Quartermaster Corps, N. J.
KING, CHARLES G. Y., Lieutenant Commander, Illinois Naval Reserve
KRAUSE, ARTHUR E., Field Aide, Naval Consulting Board, Hudson Co., N. J.
LAWRENCE, SAMUEL E., Junior Mechanical Engineer, U. S. Engineer Department
LOEWENSTEIN, LOUIS C., Plattsburg Military Training Camp, August 1916, preparatory to Reserve Officers' Corps
McMUNN, WILLIAM N., Commander, Illinois Naval Reserve
MAAS, E. F., Chief Draftsman, Machinery Division, Navy Yard, Puget Sound, Wash.
MANSFIELD, JULIAN B., Captain, Infantry and Artillery, Reserve
MARTIN, KINGSLEY G., Private, Class B, Depot Battalion, 22d Regiment of Engineers
MOON, HARTLEY A., Major, Infantry, 4th Battalion, 3d Regiment
NAEGELEY, JOHN C., Engineer and Architect, Member Navy League, U. S.
NORRIS, ALEX. MURDOCH, Ensign, Engineer Duties, Maryland Naval Militia
OATLEY, HENRY B., Naval Militia
PELLY, JOHN F., Corporal, Battery A, 1st F. A. Pa.
PIGOTT, R. J. S., Chairman Local Committee, Naval Consulting Board, Bridgeport, Conn.
RICHARDSON, EDWARD BRIDGE, Captain, Battery A, Massachusetts Field Artillery
ROBINSON, C. SNELLING, Associate Member, Naval Consulting Board, Director for State of Ohio
SCHLANK, ELIAS, Private, Sanitary Division, 7th N. Y. Infantry, National Guard.
SCOTT, ROSSITER STOCKTON, Corporal, Battery A, Maryland National Guard
SIMPSON, COLIN C., JR., Private, Depot Battalion, 7th New York Infantry
TAYLOR, DONALD F., Private, Squadron A, Machine Gun Battery, New York Division
TURNER, ROBERT T., JR., Gunner, N. Y. Training Battery
VIETS, HARRY A., Sergeant, 13th Coast Defense Command, National Guard, New York
WHITNEY, HERBERT A., Assistant Battery Commander, Coast Artillery, National Guard
WILSON, ALFRED BARBER, Acting Corporal, Company B, 8th Training Regiment, Plattsburg, N. Y.
WILSON, HENRY C., Major, 8th Coast Defense Command, National Guard, New York
WOODRUFF, CLARENCE A., Second Lieutenant, Connecticut Coast Artillery Corps
YORK, HERBERT W., Lieutenant Commander, Naval Militia, New York
ZIMMERMAN, OLIVER B., Major, Engineers, Engineers Supply Service

CORRESPONDENCE

TO THE SECRETARY:

I have been interested to note, in the Roll of Honor published in the August and September issues of The Journal, that a large part of our membership is rendering most valuable service in the work now being undertaken to put the country in a state of preparedness against attack.

This prompts me to call attention to those members of the Society I happen to think of just now who have served their country in the past, and to whom credit should also be given for the work they did in their time. For example, your past and present membership includes a number who, to my knowledge, had actual war service in the War of the Rebellion or the Spanish-American War.

To cite cases familiar to me, the list of Past-Presidents includes Thurston, Leavitt, Loring, and Melville of the Navy, and Meier and Hunt of the Army. Vice-Presidents include Shock, Charles Emery, Kafer, Manning and Morgan of the Navy, and Gilmore, a distinguished officer in the Army. Your present Treasurer, Maj. William H. Wiley, was an officer in the Army, and there must be many I cannot recognize among your deceased or living members who served in the War of the Rebellion or the Spanish-American War.

To mention my own service, it included four years' active duty as an Engineer in the Navy, 1861 to 1866, and I had also the privilege of serving on the Endicott Fortification Board in 1887.

My late illness and my age have put me on the shelf, but I am proud of being one of the old timers who did their task when they were able.

JOSEPH MORGAN.

Johnstown, Pa.

ENGINEERING SOCIETIES BUILDING UNDERGOING ALTERATION

Alterations to the Engineering Societies Building to accommodate the Civil Engineers and provide for an enlarged library are now in progress. The existing framework of the building was not designed to take care of increases in loading, and so to carry the three stories to be added it is necessary to put in four new columns from the foundation up through the existing building. The additional load entailed by the three new stories will be carried by an ingenious truss system from which the stories will be hung.

It is anticipated that this preliminary work will be finished before our Annual Meeting, and that the entire work of adding the three stories will be completed within a year.

THE ENGINEER

Under the above title, the New York *Globe* published, on August 25, an article by Dr. Frank Crane, which will be of interest as illustrating the light in which the engineer is regarded by a noted editorial writer. Incidentally, Dr. Crane quotes H. L. Gantt, Mem.Am.Soc.M.E., Chairman of the Meetings Committee. The article follows:

THE ENGINEER

DR. FRANK CRANE

The man of the future will be the engineer.

He is the man who can Do things; and is better than the man who Owns things.

The Millionaire is a temporary, passing, makeshift product of civilization. He is merely holding things together until the people get sense enough to do their own owning.

Some day little boys will read that the world once had millionaires and huge private wealth units, just as they will one day read and wonder that men once had kings.

But the official who will forever be indispensable is the engineer.

The time will come when the President of the United States will be chosen as the man who has the greatest talent and skill in organizing public works. There will be no more politics in his selection than there is now in choosing the master mechanic of a railway or factory.

When a nation goes to war nowadays, that is, when it becomes necessary to exert its supreme collective strength, nobody dreams of electing the most popular politician or the cleverest speechmaker to lead the armies. It is the man who can get the last ounce of efficiency out of men and metal that is wanted.

Some day the nation will realize that it is continually in a crisis, and that in peace as in war we need the highest order of efficiency and organization.

We need the Engineer to arrange the transportation of people and goods from place to place, without waste, without competition, without graft, looking only to the public good.

We need the Engineer to get meat, bread, and milk from farm to citizen, without the present inefficient tangle of trusts and middlemen working at cross purposes.

We need the Engineer to turn the profit of public enterprise toward building good roads and bridges, instead of enriching a few shrewd manipulators.

We need the Engineer to manage a city as economically and smoothly as if it were a manufacturing plant.

We need the Engineer to organize the farmers so that all can work together for each and their products be marked without being preyed upon at every step of the way from farm to household.

Wealth can be taken away from us. But the power to Do things cannot be taken away.

The Millionaires could go and not be missed. The Engineers we cannot spare.

"What availeth all thy wealth?" said the ancient philosopher. "He that hath better iron than thou will come and take away all thy gold."

Says H. L. Gantt:

"The man who knows what to do and how to do it is preeminently the engineer. The new world which is being ushered in by the great struggle now taking place is one in which the engineer is destined to be the supreme power, for it is becoming clear that, in future, the man who OWNS THINGS will not be as important a factor in the world as the man WHO CAN DO THINGS."

NATIONAL RESEARCH COUNCIL

The National Research Council, established by the National Academy of Sciences at the request of the President of the United States, held its organizing meeting, on September 20, at the Engineering Societies Building in New York City.

The purpose of the council is to bring into coöperation existing governmental, educational, industrial, and other research organizations, with the object of encouraging the investigation of natural phenomena, the increased use of scientific research in the development of American industries, the employment of scientific methods in strengthening the national defense, and such other applications of science as will promote the national security and welfare.

The council is composed of leading American investigators and engineers, representing the army, navy, Smithsonian Institution, and various scientific bureaus of the Government; educational institutions and research foundations, and the research laboratories of industrial and manufacturing establishments.

The members of the council have been appointed as broadly representative of the scientific and engineering professions of the country, but without attempting to represent officially the great number of societies whose activities are related to its work.

Arrangements are now making for close coöperation with the leading national societies. The members of the council thus far appointed are:

Dr. L. H. Baekeland; Dr. John A. Brashear, Hon.Mem.Am. Soc.M.E.; Dr. John J. Carty, Chief Engineer, American Telephone and Telegraph Company; Dr. Edwin G. Conklin, Professor of Zoölogy, Princeton University; Dr. John M. Coulter, Professor of Botany, University of Chicago; Brigadier-General William Crozier, Chief of Ordnance, U. S. A.; Mr. Gano Dunn, Mem.Am.Soc.M.E., President, The J. G. White Engineering Corporation; Dr. Simon Flexner, Director Rockefeller Medical Institute; Brigadier-General William Crawford Gorgas, Surgeon-General, United States Army; Dr. W. F. M. Goss, Mem.Am.Soc.M.E.., Dean of Engineering, University of Illinois; Dr. George E. Hale, Director, Mt. Wilson Solar Observatory; Mr. Clemens Herschel, President American Society of Civil Engineers; Dr. William H. Holmes, Curator, United States National Museum; Dr. W. W. Keen, President American Philosophical Society; Mr. Van H. Manning, Director, Bureau of Mines; Prof. Charles F. Marvin, Chief, United States Weather Bureau; Prof. A. A. Michelson, Director Ryerson Physical Laboratory, University of Chicago; Dr. Robert A. Millikan, Professor of Physics, University of Chicago; Dr. Arthur A. Noyes, Director Research Laboratory of Physical Chemistry, Massachusetts Institute of Technology; Prof. E. C. Pickering, Director Harvard College Observatory; Dr. Michael I. Pupin, Professor of Electro-Mechanics, Columbia University; Mr. Charles F. Rand, President, United Engineering Society; Prof. Theodore W. Richards, Director of the Walcott Gibbs Memorial Laboratory, Harvard University; Mr. O. E. Skinner, Director, Research Laboratory, Westinghouse Electric & Manufacturing Company; Lieutenant-Colonel George O. Squier, U. S. A., Chief Signal Officer, United States Army; Dr. S. W. Stratton, Mem.Am.Soc.M.E., Director, Bureau of Standards; Mr. Ambrose Swasey, Hon. Mem.Am.Soc.M.E.; Chief Constructor David W. Taylor, U. S. Navy; Dr. Elihu Thomson; Dr. C. R. Van Hise, President of the American Association for the Advancement of Science; Dr. Victor Clarence Vaughan, Director Medical Research Laboratory, University of Michigan; Dr. Charles D. Walcott, Secretary, Smithsonian Institution; Dr. William H. Welch, President of the National Academy of Sciences; Dr. W. R. Whitney, Director of the Research Laboratory, General Electric Company.

The Engineering Foundation has given its coöperation and support, and is putting the services of its Secretary, Dr. Cary T. Hutchinson, at the disposal of the Council.

FEDERAL NITRATE PLANT

The National Defense Act (H. R. 12766) empowers the President to make an investigation "to determine the best, cheapest, and most available means for the production of nitrates and other products for munitions of war and useful in the manufacture of fertilizers and other useful products by water power or any other power as in his judgment is the best and cheapest to use," and authorizes him to construct and operate such a plant or plants, appropriating the sum of $20,000,000 to carry out the purposes of the act.

At the request of the Secretary of War, the president of the National Academy of Sciences has appointed a committee to act in coöperation with the American Chemical Society for the purpose of furnishing the War Department with "a report containing such information as will aid the Department, to the greatest degree which the Academy finds practicable, in reaching a conclusion as to the best method to be followed in the manufacture of nitric acid by a process not involving dependence upon a foreign source of supply, the report to take into consideration the legislation contained in Section 124 of the National Defense Act, approved June 3, 1916. This committee, which is a sub-committee of the National Research Council, consists of the following members: Dr. Arthur A. Noyes (Chairman), Director Research Laboratory of Physical Chemistry, Massachusetts Institute of Technology; Dr. W. R. Whitney, Director of the Research Laboratory, General Electric Company; Dr. L. H. Baekeland, President of the General Bakelite Company; Dr. Charles H. Herty, President of the American Chemical Society; Warren K. Lewis, Professor of Chemical Engineering, Massachusetts Institute of Technology; Prof. Theodore W. Richards, Director of the Wolcott Gibbs Memorial Laboratory, Harvard University; Dr. Elihu Thomson, General Electric Company, Lynn, Mass.; Gano Dunn, Mem.Am.Soc.M.E.; President, The J. G. White Engineering Corporation; and Dr. M. I. Pupin, Professor of Electro-Mechanics, Columbia University.

The American Electrochemical Society, through its Committee on Public Relations, constituted of the president and past-presidents of the society (among them Lawrence Addicks,

Mem.Am.Soc.M.E.), has expressed the opinion that this legislation is unwise.

In a note addressed to the President, the Secretary of the Navy, and the Secretary of War, it is pointed out that the prime necessity of the hour is the prompt provision of an 18-months' supply on a war basis of Chilean nitrate, to be stored at various strategic points. They deprecate the entrance of the Government into an industrial field that can, in their opinion, be much better and more rapidly developed by private interests.

They further state that the processes to be considered may be classified into those producing nitric acid by direct union of the nitrogen and oxygen of the air, such as the Birkeland-Eyde and the Pauling processes; those producing ammonia by direct union of nitrogen and hydrogen, such as the Haber process; those which fix nitrogen in a complex compound, such as the cyanamid process; the action of nitrogen-fixing bacteria in natural fertilizers; and finally, natural sources of fixed nitrogen, the only one which is of sufficient magnitude to warrant consideration being by-product ammonia derived from the distillation of coal.

All of the foregoing processes, except the arc processes, produce ammonia, and, as this and not nitric acid is the chief desideratum for fertilizer purposes, there is not sufficient commercial incentive for the carrying of these ammonias of varying degrees of purity through the nitric acid required in the manufacture of explosives. The Committee urges that instead of direct action toward the production of nitrate, the research facilities of the Government be concentrated (1) on the oxidation of ammonia, and (2) on the *modus operandi* of nitrogen-fixing bacteria, the former investigation to be carried out by the U. S. Bureau of Mines, and the latter by the U. S. Bureau of Soils.

NAVAL CONSULTING BOARD

The members of the Naval Consulting Board met in Washington on September 19 to take the oath of allegiance prescribed by the recently enacted naval appropriation law, which gives legal status to the members of this body. Those present were Thomas A. Edison, Hon. Mem.Am.Soc.M.E.; Dr. M. R. Hutchison, Mem.Am.Soc.M.E.; Dr. W. R. Whitney and Dr. L. R. Backeland, both members of the American Chemical Society; Frank J. Sprague, Mem.Am.Soc.M.E.; R. S. Woodward, President of the Carnegie Institute, and Professor Arthur G. Webster, both members of the American Mathematical Society; A. M. Hunt, Mem.Am.Soc.M.E.; Spencer Miller, Mem.Am.Soc.M.E., and William Le Roy Emmet, Mem.Am.Soc.M.E., both representing the Society; Matthew B. Sellers and Hudson Maxim, representing the American Aeronautical Society; Dr. Peter Cooper Hewitt and Thomas Robins, representing the Inventors' Guild; Howard E. Coffin, Mem.Am.Soc.M.E., and Andrew L. Riker, Mem.Am.Soc.M.E., representing the Society of Automobile Engineers; Elmer A. Sperry, Mem.Am.Soc.M.E., representing the American Society of Aeronautic Engineers; Wm. L. Saunders, Mem.Am.Soc.M.E., representing the American Institute of Metals; and Lawrence Addicks, Mem.Am.Soc.M.E., representing the American Electrochemical Society. Four members of the Board were unable to attend the meeting, namely, B. G. Lamme, of the American Institute of Electrical Engineers; Alfred Craven, of the American Society of Civil Engineers; Benjamin B. Thayer, of the American Institute of Mining Engineers; and Dr. J. W. Richards, of the American Electrochemical Society.

The board elected Mr. Edison as Chairman, Messrs. Saunders and Hewitt as Vice-Chairmen, and Mr. Robins as Secretary. Considerable time was given to the discussion of plans for the establishment of the $1,500,000 naval research laboratory to be built by the Government, and a special committee consisting of Messrs. Edison, Whitney, Baekeland, Sprague, Robins, and Addicks was appointed to report to the board as to the best site for it. It is stated that while most of the members of the board favor the selection of New York City, officials of the Navy Department prefer Washington as a site, in order to have the laboratory close to the Navy Department, the naval gun shops, and the naval proving grounds.

CORRECTION

Prof. E. A. Fessenden calls attention to a typographical error in the authors' closure to the discussion of the paper by Professor Hedrick and himself, entitled On the Transmission of Heat in Boilers, published in the August issue.

On pages 624 and 625, in equations [1a], [1b], [1] and [2], and the unnumbered equation in the middle of the first column on page 625, in every case the division sign (÷) should be a plus sign (+).

BOILER CODE COMMITTEE

The Boiler Code Committee meets monthly for the purpose of considering communications relative to the Boiler Code. Any one desiring information as to the application of the Code is requested to communicate with the Secretary of the Committee, Mr. C. W. Obert, 29 West 39th Street, New York.

There will be a public hearing on the Code, the first since the adoption of the Code two years ago, on Friday, December 8, at 2 p. m.

NEW YORK SECTION EXCURSION

On Friday, September 15, seventy-one members and guests of the New York Section visited the plants of the Ford Motor Company and the Loose-Wiles Biscuit Company at Long Island City. At the Ford plant the visitors had an opportuunity to witness the complete assembling of the various models of cars, including the body, chassis, and motor.

At the Loose-Wiles Company special arrangements were made to give the visitors every opportunity to inspect the mechanical features of the various labor saving machines which have been developed in the baking industry.

This is the fourth technical excursion held by the New York Section during the summer.

It is the endeavor of the New York Committee to develop the interest of the members in each other, and on these excursions the opportunity for increase of acquaintanceship is offered, as well as the visit to places of engineering interest.

RUTGERS COLLEGE ANNIVERSARY

The celebration of the 150th anniversary of the founding of Rutgers College, New Brunswick, N. J., will take place on October 13-15.

The program of the celebration includes commemoration exercises, an historical address by Dr. W. H. S. Demarest, president of the college, an anniversary pageant and an anniversary dinner to delegates and guests.

The President and Secretary of the Society will attend.

APPLICATIONS FOR MEMBERSHIP

MEMBERS are requested to scrutinize with care the following list of candidates who have filed applications for membership in the Society. These are subdivided according to the grades for which their ages qualify them, and not with regard to professional qualifications, i.e., the ages of those under the first heading place them under either Member, Associate or Associate-Member, those in the next class under Associate-Member or Junior, and those in the third under Junior grade only. Applications for change of grading are also posted.

The Membership Committee, and in turn the Council, urge the members to assume their share of the responsibility of receiving these candidates into membership by advising the Secretary promptly of any one whose eligibility for membership is in any way questioned. All correspondence in regard to such matters is strictly confidential, and is solely for the good of the Society, which it is the duty of every Member to promote. Unless objection is made to any of the candidates posted by November 10, 1916, and providing satisfactory replies have been received from the required number of references, these candidates will be balloted upon by the Council. Those elected to membership will be notified about December 15, 1916.

NEW APPLICATIONS

FOR CONSIDERATION AS MEMBER, ASSOCIATE OR ASSOCIATE-MEMBER

ADAMS, ROBERT B., Assistant Superintendent, New England Westinghouse Co., Meriden, Conn.

BENNETT, HOWARD D., Consulting, Mechanical and Dredge Engineer, Baltimore, Md.

BUCHANAN, R. H., Mining Engineer, Coal Department, The Delaware & Hudson Co., Scranton, Pa.

BURKE, JAMES, President, Burke Electric Co., Erie, Pa.

BURROUGHS, CHARLES F., President, Charles Burroughs Co., Newark, N. J.

CLARK, EARL A., Consulting Engineer, Clark & Shade, Tulsa, Okla.

CLARK, EZRA E., Inspector and Engineer, Associated Factory Mutual Fire Insurance Cos., Boston, Mass.

CLEMONS, SAMUEL W., in Mechanical Engineering Department, Draper Co., Hopedale, Mass.

COONEY, ROBERT L., Automatic Sprinkler Co. of N. Y., Atlanta, Ga.

COOPER, GEORGE H., Chief Engineer, Manhattan Electrical Supply Co., Jersey City, N. J.

CURRY, FREDERICK H., Plant Superintendent, Hudson Motor Car Co., Detroit, Mich.

DATZ, LOUIS C., Engineer, Southern Properties, United Gas & Elec. Engrg. Corp., Birmingham, Ala.

DOD, FREDERIC H., Locomotive Superintendent, Manila Railroad Co., Rizal, P. I.

DORON, WILLIAM H., Maintenance Engineer, Standard Aniline Products, Inc., Wappingers Falls, N. Y.

DOURSON, LOUIS A., Designer and Checker, The Lunkenheimer Co., Cincinnati, O.

DUGDALE, RICHARD M., Supervisor, Remington Arms & Ammunition Co., Ilion, N. Y.

EVANS, VICTOR W., Sales Engineer, The Jeffrey Mfg. Co., New York, N. Y.

FERRY, OLIVER N., Mechanical Engineer, Ashcroft Mfg. Co., Bridgeport, Conn.

FORSYTHE, CLAYTON E., Consulting Engineer, Morrow Mfg. Co., Elmira, N. Y.

GASSMAN, HOWARD M., Consulting Engineer, Birmingham, Ala.

GOODMAN, WILLIAM, Manager, Laidlaw Plant, Worthington Pump & Mchy. Co., Cincinnati, O.

HAY, PAUL L., Contracting Engineer, Samuel W. Hay's Sons, Pittsburgh, Pa.

HENDERSON, JOHN M., Mechanical Engineer and Master Mechanic, Rome Brass & Copper Co., Rome, N. Y.

HUGHES, HENRY E., Mechanical Engineer, E. I. Du Pont de Nemours & Co., Wilmington, Del.

HULSE, GEORGE E., Chief Engineer, Safety Car Heating & Lighting Co., New York, N. Y.

HUNT, HARRY B., Engineer, Sales Department, American Locomotive Co., New York, N. Y.

ILLGES, GEORGE M., Manager and Engineer, Chicago Office, Harrisburg Fdry. & Mch. Co., Heine Safety Boiler Co., Chicago, Ill.

JOHNSON, J. ADOLPH, Mechanical Superintendent, The M. B. Schenck Co., Meriden, Conn.

JOHNSON, J. EDWARD, Superintendent, Mechanical Department, Connecticut Tel. & Elec. Co., Inc., Meriden, Conn.

KAISER, WILLIAM, Genl. Supt. of Operation and Construction, The Barrett Co., Birmingham, Ala.

KESSLER, CLAUDE H., Senior Mechanical Engineer, Interstate Commerce Commission, San Francisco, Cal.

MERRIAM, I. B., JR., President, Chattanooga Boiler & Tank Co., Chattanooga, Tenn.

MOHLER, VALENTINE J., Woodcliff-on-Hudson, N. Y.

NEILD, ROBERT R., Manager, Victoria Machinery Depot Co., Ltd., Victoria, B. C.

PATTON, THOMAS A., In Charge of Gages and Gage Supervision, Baldwin Locomotive Wks., Eddystone, Pa.

PAULI, CARL F. G., Advisory Engineer, Linerusta Wks., Pallas, N. Y.

PERSIANI, CHARLES C., Treasurer, Clark Bros. Bolt Co., Milldale, Conn.

POLLAK, JULIAN A., Secretary, The Pollak Steel Co., Cincinnati, O.

POWER, GEORGE S., Dept. Mgr., Supt. and Mech. Engr., Wickes Bros., Saginaw, Mich.

RICE, GEORGE B., Consulting Chief Engineer, Schoelkopf Aniline & Chemical Wks., Inc., Buffalo, N. Y.

SCRIBNER, CHARLES F., Industrial Engineer, New England Westinghouse Co., Springfield, Mass.

STAPLE, SYDNEY J., Draftsman and Designer, Homestake Mining Co., Lead, S. D.

STEWART, ANDREW M., Factory Manager, The National Supply Co., Toledo, O.

SWEENY, ROBERT O., Chief Draftsman, Car Department, Chicago, St. Paul, Minneapolis & Omaha Ry., Hudson, Wis.

TITUS, FORREST M., Foreign Representative, American Locomotive Co., New York, N. Y.

WOOD, CLARK O., Special Agent in Ohio, The Home Ins. Co. of New York, Columbus, O.

FOR CONSIDERATION AS ASSOCIATE-MEMBER OR JUNIOR

BAUGHMAN, ISAAC N., Agri. Engr. and Mgr., Marseilles, Ill.

BONNET, FRANK H., Assistant Mechanical Engineer, The Buckeye Steel Castings Co., Columbus, O.

CAMP, EUGENE V., Vice-President and Chief Engineer, H. S. Jaudon Engrg. Co., Savannah, Ga.

CHASE, HENRY A., Superintendent, Cummings Mch. Works, Boston, Mass.

DENSE, JOHN C., Chief Draftsman, Morrow Mfg. Co., Elmira, N. Y.

GILL, MURRAY F., Electrical Engineer, Texas Power & Light Co., Dallas, Tex.

HARKNESS, V. F., Engineering Assistant, Public Service Elec. Co., Newark, N. J.

HELLYAR, CHARLES H., Mechanical Engineer, Remington Arms Co., Bridgeport, Conn.

HILMER, OTTO E., Consulting Engineer, With Walter G. Franz, Cincinnati, O.

JAGER, GEORGE W., Mechanical Draftsman, National Lock Washer Co., Newark, N. J.

KELLER, KAUFMAN T., Master Mechanic, Cole Motor Car Co., Indianapolis, Ind.

KOTZ, EMIL F., Designer in Engineering Department, Semet-Solvay Co., Syracuse, N. Y.

MCGRATH, F. P., Engineer of Tests, Carnegie Steel Co., Duquesne, Pa.

MCLEAN, JOHN, Efficiency Engineer, H. E. Harris Engrg. Co., Bridgeport, Conn.

MCMILLAN, WILLIAM L., Chief Insp. and Cons., Ordnance Engr., American Can Co., New York, N. Y.

MAAK, CHARLES, Assistant Chief Engineer, Metals Production Equipment Co., Springfield, Mass.

MACY, R. G., Superintendent, East Norwalk Municipal Elec. Wks., East Norwalk, Conn.

PADRON, AGUSTIN, Engineer, M. Galdo & Co., Cardenas, Cuba

PEASLEE, WILLETTS, Production Engineer, The Cincinnati Milling Mch. Co., Cincinnati, O.

RANTZ, CHARLES F., Consulting and Contracting Refrigerating Engineer, New Orleans, La.

ROONEY, H. LLOYD, Cons. Power Plant Engineer, Newport, R. I.

ROYAL, JAMES M., Designer, Diesel Engine Department, Seattle Astoria Iron Works, Seattle, Wash.

SAGENDORPH, GEORGE A., Treasurer, Penn Metal Co., Boston, Mass.

SALMON, DANIEL E., Superintendent,
H. E. Harris Engrg. Co., Bridgeport, Conn.

SLOCUM, MYLES S., Associate Engineer,
Slocum, Avram & Slocum, Inc., New York, N. Y.

SMITH, JULE C., Field Engineer, Seattle, Wash.

SNODGRASS, LARNED I., President,
Snodgrass, Hewetson Co., Cincinnati, O.

VOCKELL, WILLIAM H., In charge of Tool Designing Dept.,
Cincinnati Milling Mch. Co., Cincinnati, O.

WESTON, SAMUEL C., Safety Engineer,
The Remington Arms-U. M. C. Co., Inc., Bridgeport, Conn.

WOODS, GEORGE R., Assistant to President,
Allied Machinery Co. of America, New York, N. Y.

FOR CONSIDERATION AS JUNIOR

BENSON, ROBERT F. A., Graduate Student Course,
Westinghouse Elec. Mfg. Co., Pittsburgh, Pa.

BUELL, MAURICE L.,
Robert W. Hunt & Co., New York, N. Y.

FREDERICK, ALVAH B., In Service Office,
Burroughs Adding Mch. Co., Detroit, Mich.

GIFFELS, JOHN E. W.,
With John A. Stevens, Lowell, Mass.

KAEMMERLING, GUSTAV H., Designer,
Lehigh Car, Wheel & Axle Works, Catasauqua, Pa.

KREISER, WALTER W., Mechanical Engineer,
Western Union Telegraph Co., New York, N. Y.

LEWIS, GEORGE C., Sales Engineer,
Hersh & Brother, Allentown, Pa.

LEWIS, HARRY I., Mechanical Engineer,
Dolphin Jute Mills, Paterson, N. J.

LOGAN, LLOYD, Mechanical Draftsman,
Semet-Solvay Co., Syracuse, N. Y.

MCKISSICK, ELLISON S., Engineer,
Grendel Mills, Greenwood, S. C.

MANN, CARL P., Engineer,
With MacMullen, Riley & Durley, Toronto, Ont., Can.

NENNINGER, LESTER F., Chief Draftsman,
Cincinnati Milling Mch. Co., Cincinnati, O.

NUTTER, ASA P., Draftsman,
S. M. Green Co., Springfield, Mass.

REID, GEOFFREY L., Cost Clerk,
General Elec. Co., Lynn, Mass.

SCHWANHAUSSER, EDWIN J., Engineer, Condenser Department,
Worthington Pump & Mchy. Corp., Harrison, N. J.

SHAFFER, LAYTON S., Assistant Chief Engineer,
Ohio Locomotive Crane Co., Bucyrus, O.

TAUGEMAN, WALTER W., Sales Engineer,
Cincinnati Milling Mch. Co., Cincinnati, O.

VALDES, JESUS M., Engineer,
With John A. Stevens, Lowell, Mass.

VARIAN, HOWARD M., Chief Draftsman,
Great Lakes Engrg. Wks., Detroit, Mich.

WILLETT, Francis M., Mechanical Engineer,
H. & B. American Machine Co., Pawtucket, R. I.

PROMOTION FROM ASSOCIATE

VIETS, HARRY A., Chief Draftsman, Shell Department,
E. W. Bliss Co., Brooklyn, N. Y.

PROMOTION FROM JUNIOR

BAILEY, ALEX D., Asst. Ch. Engr., Stas. 1 and 2,
Commonwealth Edison Co., Chicago, Ill.

FABER, JOHN P., Chief Engineer,
Ransome Concrete Machinery Co., Dunellen, N. J.

NORTHRUP, FRANCIS B., In charge of Drawing Room,
The Charles Burroughs Co., Newark, N. J.

RIGDON, CARL, Superintendent, Light and Power Department,
Chattanooga Railway & Light Co., Chattanooga, Tenn.

RIPSCH, CHARLES W., Secretary,
The Sheffield Machine & Tool Co., Dayton, O.

ROBINSON, PARKER M., Industrial Engineer, representative for
H. L. Gantt, The Celluloid Co., Newark, N. J.

ROWLEY, RIDGWAY L., Assistant Engineer,
Board of Fire Underwriters, San Francisco, Cal.

STAPLES, HORACE A., Superintendent, Raw Materials Dept.,
Bridgeport Brass Co., Bridgeport, Conn.

STUNTZ, JOHN E., Superintendent and Chief Engineer,
The Cape Cruz Co., Ensenada de Mora, Cuba

VAUGHAN, AUBREY W., Industrial Engineer,
Saco-Lowell Shops, Lowell, Mass.

WILCOX, JOSEPH, JR., Machine Designer,
Norton Grinding Co., Worcester, Mass.

SUMMARY

New Applications	106
Applications for change of grading:	
Promotion from Associate	1
Promotion from Junior	11
Total	118

GEOGRAPHICAL LIST

(Applications for promotion from any grade will be indicated by the initials of that grade)

Alabama
Birmingham—Datz, L. C.
Gassman, H. M.
Kaiser, W.

California
San Francisco—Kessler, C. H.
Rowley, R. L. (J)

Canada
Toronto—Mann, C. P.
Victoria, B. C.—Neild, R. R.

Connecticut
Bridgeport—Ferry, O. H.
Hellyar, C. H.
McLean, J.
Salmon, D. E.
Staples, H. A. (J)
Weston, S. C.
East Norwalk—Macy, R. G.
Meriden—Adams, R. B.
Johnson, J. A.
Johnson, J. E.
Milldale—Persiani, C. C.

Delaware
Wilmington—Hughes, H. E.

Georgia
Atlanta—Cooney, R. L.
Savannah—Camp, E. V.

Illinois
Chicago—Bailey, A. D. (J)
Illges, G. M.
Marseilles—Baughman, I. N.

Indiana
Indianapolis—Keller, K. T.

Louisiana
New Orleans—Rantz, C. F.

Maryland
Baltimore—Bennett, H. D.

Massachusetts
Boston—Chase, H. A.
Clark, E. E.
Sagendorph, G. A.
Hopedale—Clemons, S. W.
Lowell—Giffels, J. E. W.
Valdes, J. M.
Vaughan, A. W. (J)
Lynn—Reid, G. L.
Springfield—Maak, C.
Nutter, A. P.
Scribner, C. F.
Worcester—Wilcox, J. Jr. (J)

Michigan
Detroit—Curry, F. H.
Frederick, A. B.
Varian, H. M.
Saginaw—Power, G. S.

New Jersey
Dunellen—Faber, J. P. (J)
Harrison—Schwanhausser, E. J.
Jersey City—Cooper, G. H.
Newark—Burroughs, C. F.
Harkness, V. F.
Jager, G. W.
Northrup, F. B. (J)
Robinson, P. M. (J)
Paterson—Lewis, H. I.

New York
Brooklyn—Viets, H. A. (A)
Buffalo—Rice, G. B.
Elmira—Dense, J. C.
Forsythe, C. E.
Ilion—Dugdale, R. M.
New York—Buell, M. L.
Evans, V. W.
Hulse, G. E.
Hunt, H. B.
Kreiser, W. W.
McMillan, W. L.
Slocum, M. S.
Titus, F. M.
Woods, G. R.
Pallas—Pauli, C. F. G.
Rome—Henderson, J. M.
Syracuse—Kotz, E. F.
Logan, L.
Wappingers Falls—Doron, W. H.
Woodcliff-on-Hudson—Mohler, V. J.

Ohio
Bucyrus—Shaffer, L. S.
Cincinnati—Dourson, L. A.
Goodman, W.
Hilmer, O. E.
Nenninger, L. F.
Peaslee, W.
Pollak, J. A.
Snodgrass, L. I.
Taugeman, W. W.
Vockell, W. H.
Columbus—Bonnet, F. H.
Wood, C. O.
Dayton—Ripsch, C. W. (J)
Toledo—Stewart, A. M.

Oklahoma
Tulsa—Clark, E. A.

Pennsylvania
Allentown—Lewis, G. C.
Catasauqua—Kaemmerling, G. H.
Duquesne—McGrath, F. P.
Eddystone—Patton, T. A.
Erie—Burke, J.
Philadelphia—Akimoff, N. W.
Pittsburgh—Benson, R. F. A.
Hay, P. L.
Scranton—Buchanan, R. H.

Rhode Island
Newport—Rooney, H. L.
Pawtucket—Willett, F. M.

South Carolina
Greenwood—McKissick, E. S.

South Dakota
Lead—Staple, S. J.

Tennessee
Chattanooga—Merriam, I. B., Jr.
Rigdon, C. (J)

Texas
Dallas—Gill, M. F.

Washington
Seattle—Royal, J. M.
Smith, J. C.

Wisconsin
Hudson—Sweeny, R. O.

Cuba
Cardenas—Padron, A.
Ensenada de Mora—Stuntz, J. E. (J)

Philippine Islands
Rizal—Dod, F. H.

PERSONALS

IN these columns are inserted items concerning members of the Society and their professional activities. Members are always interested in the doings of their fellow-members, and the Society welcomes notes from members and concerning members for insertion in this section. All communications of personal notes should be addressed to the Secretary and items should be received by the 18th of the month in order to appear in the succeeding issue of The Journal.

CHANGES OF POSITION

WALTER C. BECKJORD, formerly with the Madison Gas and Electric Company, has accepted a position with the American Light and Traction Company, New York.

JOHN A. MALONE, recently connected with the E. W. Bliss Company of Brooklyn, N. Y., has accepted a position with the Allied Machinery Company of America, New York, N. Y.

JOHN B. PRICE, formerly identified with the Price Electric and Machinery Company, Richmond, Va., has become associated with the Peerless Electric Company of Warren, O.

JOHN R. GRAY has severed his connection with the Louisiana State Rice Mill Company at New Orleans, and has taken charge of the Iota, La., plant of the Iota Rice Milling Company, Inc.

HENRY R. COBLEIGH, formerly mechanical editor of The Iron Age and more recently managing editor of Power, has become a partner in the Power Plant Management Company, New York.

HOWARD S. RIDDLE, consulting engineer of the Ohio Board of Administration, Columbus, O., resigned October 1 to accept a position with the Jeffrey Manufacturing Company, also of Columbus.

OSCAR H. WIESE, formerly employed by the Mackintosh and Seymour Company, Auburn, N. Y., has been engaged by the Baltimore Oil Engine Company, Baltimore, Md., as designer.

PERRY S. TONEY has entered the employ of Neiler Rich and Company, Chicago, Ill., as mechanical engineer. He was until recently clerk with the Automatic Electric Company of the same city.

CYRUS W. BASSETT, until recently engineer with the Elevator Supply and Repair Company, Chicago, Ill., has become affiliated with the Budd Manufacturing Company of Philadelphia, Pa.

FRANK L. EIDMANN, formerly efficiency engineer with the American La France Fire Engine Company, Elmira, N. Y., has resigned to accept a position with the Heald Machine Company, Worcester, Mass.

W. HOWARD ZABRISKIE, until recently foreman of the Standard Oil Company of New York, Long Island City, N. Y., has become affiliated with the Standard Oil Company of California, Richmond, Cal.

DAVID R. SWINTON has accepted a position in the engineering department of The Perfection Spring Company, Cleveland, O. He was formerly in the employ of the Tuthill Spring Company, Chicago, Ill.

CARROLL D. BILLMYER, formerly draftsman of the Norfolk and Western Railway, Roanoke, Va., has accepted the position of instructor of mechanical engineering at Throop College of Technology, Pasadena, Cal.

HARRY KAPLAN, formerly efficiency engineer with the Lewiston Bleachery and Dye Works, Lewiston, Me., has accepted a similar position with the Winchester Repeating Arms Company, New Haven, Conn.

BARTON CRUIKSHANK has assumed the position of New York manager of The C. G. Garrigus Machine Company. He was until recently associated with the Ashcroft Manufacturing Company of Bridgeport, Conn.

DAVID A. CHAPMAN, formerly mechanical engineer with Wm. Filene's Sons Company, Boston, Mass., has become associated with The Touraine Company of Boston, Mass., and the Dangel Company, Everett, Mass.

ALFRED L. KENYON, formerly manager of the Anniston and Attala operations of the Alabama Power Company, Anniston, Ala., is now connected with the Columbia Railway, Gas and Electric Company, Columbia, S. C.

WILBUR C. PRIOR has assumed the duties of chief draftsman of The Merrow Machine Company, Hartford, Conn. He was formerly identified with the Aetna Life Insurance Company of the same city as inspector.

E. R. KENNER, formerly sales engineer for the Allis-Chalmers Manufacturing Company in their Cleveland district, has resigned and entered the engineering department of the Firestone Tire and Rubber Company, Akron, O.

ALBERT C. THOMAS, formerly resident chief engineer of the Alpha Portland Cement Company, Cementon, N. Y., has assumed the duties of mechanical superintendent of the Canadian Salt Company, Windsor, Ont., Canada.

FRANK E. WATKINS has resigned his position as works manager of the East Jersey Pipe Corporation at Paterson, N. J., to accept a similar position with the Canadian Fairbanks-Morse Company, Ltd., Toronto, Ont., Canada.

HORACE R. WENTZELL, until recently production engineer with the Curtiss Motor Company of Buffalo, N. Y., has become connected with the Buick Motor Car Company, Flint, Mich., in the capacity of assistant master mechanic.

ELMER E. GIBSON has assumed the duties of superintendent of The Ashcroft Manufacturing Company, Bridgeport, Conn. He was formerly associated with The Jones Speedometer Company of New Rochelle, N. Y., in a similar capacity.

T. E. BUCK has accepted a position with the Donora Steel Company, Donora, Pa., as draftsman. He was formerly connected in a similar capacity with the Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa.

FRANK E. BARDROF has severed his connection with the Rensselaer Polytechnic Institute, Troy, N. Y., and has assumed the duties of draftsman in the mechanical engineers' office of the Pennsylvania Railroad, Altoona, Pa.

THOMAS M. LYNCH has accepted a position with the Babcock and Wilcox Company, Bayonne, N. J. He was until recently connected with the Buena Vista Extract Company, Buena Vista, Va., in the capacity of assistant manager.

MERRITT VAN VALKENBURGH, formerly in the employ of the De La Vergne Machine Company, New York, as draftsman in the power installation department, is now associated with Westinghouse, Church, Kerr and Company of New York.

SAMUEL P. BLAKEMAN, until recently associated with The Terry Steam Turbine Company, Hartford, Conn., in the capacity of draftsman and designer, has joined the staff of the S. K. F. Ball Bearing Company, Hartford, Conn., as mechanical engineer.

HUGH H. HARGRAVE has become affiliated with the piping department of the Newport News Shipbuilding and Dry Dock Company, Newport News, Va. He was formerly connected with W. J. Rainey of Uniontown, Pa., in the capacity of designer.

JAMES H. MARKS, formerly superintendent of the buildings and grounds department of the University of Michigan, Ann Arbor, Mich., is now superintendent of maintenance and construction of the Packard Motor Car Company, Detroit, Mich.

WILLIAM E. MOSHER has entered the employ of the Fruit Dispatch Company, New York. He was until recently associated with the horticultural and pomological investigations of the U. S. Department of Agriculture, Washington, D. C.

EDWIN A. FESSENDEN has severed his connection with the University of Missouri, Columbia, Mo., as associate professor of mechanical engineering to become professor of mechanical engineering at Pennsylvania State College, State College, Pa.

LEE E. WALKER has accepted the position of foreman with the Baldwin Munition Company at Eddystone, Pa. He was until recently in the employ of The Good Roads Machinery Company, Inc., Philadelphia, Pa., in the capacity of district manager.

CHARLES H. PHILLIPS has severed his connections as tool designer with the Pierce-Arrow Motor Car Company, Buffalo, N. Y., and is now associated with the Curtiss Aeroplane and Motor Corporation, Buffalo, N. Y., in the capacity of superintendent of tools.

JILES W. HANEY has accepted a position in the mechanical engineering department of Pennsylvania State College, State College, Pa. He was until recently connected with the Commerce Power Company, Kansas City, Mo. in the capacity of chief engineer.

GEO. H. CUNNINGHAM has resigned his position as superintendent of construction with the Anaconda Copper Mining Company and accepted the position of chief engineer for the Electrolytic Zinc Company of Australia, with headquarters at Hobart, Tasmania.

HOWARD M. CHANDLER, formerly superintendent of construction of the Board of Home Missions of Presbyterian Church of New York at San Germán, P. R., has become affiliated with the Honolulu Iron Works Company, New York, in the capacity of mechanical engineer.

WILLIAM H. TABOR has entered the employ of the Winchester Repeating Arms Company, New Haven, Conn., in the capacity of assistant industrial engineer of the tool department. He was until recently instructor of industrial engineering at Pennsylvania State College, State College, Pa.

M. WILLIAM EHRLICH, formerly editor of Electrical Age, associate editor of Metal Worker and who has had seven years practice with consulting engineers, has joined the Lefax editorial staff, Philadelphia, Pa. He will assist in standardizing the magazine and will carry out the plan for issuing a new Lefax cost data class which will consist of four additional sheets a month.

WALTER G. HOLMES, formerly associated with the Wilmot Castle Company, Rochester, N. Y., as mechanical engineer, has become identified with the Standard Medical Supply Company of Minneapolis, Minn., manufacturers and jobbers of physicians', dentists', hospital and veterinaries' supplies and manufacturers of X-ray apparatus and pharmaceutical preparations. Mr. Holmes, patentee of the Holmes sterilizer, has spent many years in the manufacture of medical appliances and is now superintending the manufacture of the sterilizer, the Campbell electric cabinet and white enamel furniture and also the X-ray machines.

APPOINTMENTS

THOMAS E. KEEFE has been appointed New York representative of the Franklin Oil and Gas Company of Bedford, O.

EMILE J. BAYLE has been appointed assistant to the president, and production engineer with the Pfaudler Company, Rochester, N. Y.

G. L. KNIGHT has recently been appointed chairman of the Electrical Apparatus Committee of the National Electric Light Association.

O. W. COOK, manager of works with the Canadian Cartridge Company, Limited, Hamilton, Ont., Canada, has recently been appointed manager of that company.

S. M. MARSHALL, manager of the turbine department of the Southwark Foundry and Machine Company, Philadelphia, Pa., has been appointed chief engineer of the company.

CARL STENBOL, mechanical engineer of the steel department of the Canada Cement Company, Limited, Montreal, Canada, has been appointed superintendent of the steel and forge departments of the company.

JAMES MACFARLANE, for many years superintendent of the dredging division of the Panama Canal, Paraiso, has been appointed to succeed J. J. Eason as assistant superintendent of the mechanical division at Balboa.

WILLIAM MCCLELLAN, consulting engineer of New York City and former chief engineer for the New York Public Service Commission for the Second District, has been appointed dean of the Wharton School of Finance and Commerce of the University of Pennsylvania, Philadelphia, Pa.

H. SCHRECK has been appointed chief engineer of the Diesel engine department of the Fulton Iron Works of St. Louis. His former position with this company has been assistant chief engineer. Mr. Schreck has had a wide experience with one of the most prominent concerns in Europe in whose shops he superintended for years the manufacture of the Diesel engine, participating as a co-worker in their development, both of the marine and the stationary type.

ANNOUNCEMENTS

LAUREL E. FRANCE has become associated with the Braden Copper Company, Rancagua, Chile.

SAMUEL S. WYER is in the Petrolia, Texas, natural gas fields investigating natural gas conditions there.

WILLIAM I. BALLENTINE has become identified with The Chain Belt Company of Milwaukee, Wis.

JOHN J. MATSON has become associated with the General Electric Company of Schenectady, N. Y.

CHARLES W. LUMMIS of Worcester, Mass., has recently been granted a patent for an ingot mold.

W. J. STOOP has assumed the duties of superintendent of the Wilmington Steel Company, Wilmington, Del.

A. A. POTTER has been elected a member of the Council of the Society for the Promotion of Engineering Education.

STEPHEN THOMAS has accepted a position in the efficiency department of the Barney and Smith Car Company, Dayton, O.

HOLLIS GODFREY has been elected First Vice-President of the Society for the Promotion of Engineering Education.

PETER JUNKERSFELD of Chicago has been elected president of the Association of Edison Illuminating Companies.

W. M. THORNTON has been elected Second Vice-President of the Society for the Promotion of Engineering Education.

H. M. BYLLESBY, president of H. M. Byllesby and Company, is making a tour of inspection of the company's properties in Colorado.

A shaft coupling has been patented by JULIAN KENNEDY, Vice-President, Am.Soc.M.E. The patent number is 1,194,028.

ALFRED R. BENCH has become identified with the sales department of the Taylor-Wharton Iron and Steel Company, High Bridge, N. J.

ROBERT E. CRANSTON, mining engineer of San Francisco, Cal., is on an extended professional trip through Colorado, Montana and Nevada.

SAMUEL E. FLEXER has been promoted to the position of general superintendent of the Kingsport, Tenn., plant of the Clinchfield Portland Cement Corporation.

JAMES L. MYERS, formerly with the Philadelphia, Pa., office of The Barrett Company, has been transferred to the Gray's Ferry Plant in the capacity of fuel and power engineer.

ROBERT E. HALL, formerly vice-president and sales manager of The Goulds Manufacturing Company, Seneca Falls, N. Y., has been transferred to the Chicago, Ill., office of the company.

CHARLES C. JAMIESON and GEORGE H. HOUSTON have formed a partnership under the name of Jamieson and Houston, for investigating, consulting and management work, with offices in New York.

WILLIAM MCCLELLAN, F. B. H. PAINE and HORACE T. CAMPION announce that they have formed the partnership of Paine, McClellan and Campion, engineers, with offices in New York City and Philadelphia.

JOHN F. MAGEE, formerly connected with the engineering department of the Alpha Portland Cement Company, Easton, Pa., has been transferred to the Martins Creek, Pa., plant in the capacity of superintendent of Mill No. 4.

JOHN L. THOMPSON, supervising engineer of The Travelers Insurance Company and the Travelers Indemnity Company, Hartford, Conn., is now in general charge of the engineering and inspection division with the title of superintendent.

CHARLES E. BECK has opened an office in the Victor Building, Kansas City, Mo., as district manager for the De La Vergne Machine Company of New York. The company's Chicago office, formerly in charge of Mr. Beck, will be discontinued.

ALLAN D. RISTEEN, affiliated with the engineering and inspection division of the Travelers Insurance Company and the Travelers Indemnity Company, Hartford, Conn., has assumed the duties of director of technical research and safety publication work.

HARRY C. LANE, formerly chief draftsman and superintendent of construction of the Maryland Steel Company, has been made assistant chief engineer and superintendent of construction, since the purchase of the plant by the Bethlehem Steel Company.

H. R. SETZ, for the past four years in charge of the oil engine department of the Fulton Iron Works, has resigned this position. He will devote the next few months to research and development work preparatory to bringing out a new type of engine.

GEO. G. SCHMIDT, secretary of The New York School of Heating and Ventilating, announces the opening of the fourth annual season of the school, and the inauguration of a second year course comprised of twelve lectures.

BURT H. WESTON, formerly instructor in mechanical and engineering drawing and machine design, David Ranken Jr. School of Mechanical Trades, St. Louis, Mo., has resigned and opened an office in Dayton, O. Mr. Weston will enter business as a consulting and equipment engineer.

ERWIN W. THOMPSON, commercial attaché for Germany, the Netherlands and the Scandinavian countries, has returned to this country to spend several months on official duty, and will be prepared to confer with representative bankers, merchants and manufacturers regarding trade conditions in his district, as well as to address commercial gatherings. During his incumbency of the post of commercial attaché, Mr. Thompson was temporarily stationed at The Hague, Netherlands, and a large part of his time was devoted to assisting American merchants and manufacturers in connection with the various prohibitory trade enactments of the warring nations. He has been instrumental in obtaining the lifting of several embargos and in effecting a change in some of the methods adopted by the governments and by the Netherlands Overseas Trust in regard to the operation of the enactments referred to.

AUTHORS OF PAPERS, ETC.

An article on Laying Out Skew Bevel Bears by REGINALD TRAUTSCHOLD, appears in the September number of *Machinery*.

H. L. GANTT has contributed an article entitled, What is Preparedness, to the September number of *The Engineering Magazine*.

WILLIAM A. KNIGHT has contributed an article on Cutting Speeds and Feeds to the September 7 issue of the *American Machinist*.

ROY A. SEATON is the author of a book entitled Concrete Construction for Rural Communities.

HOWARD E. COFFIN is the author of an article entitled The Council of National Defense, published in the September issue of *The Engineering Magazine*.

An article on Power Equipment for the Steam Plant by ROBERT L. STREETER, is published in the September issue of *The Engineering Magazine*.

H. J. MACINTIRE has contributed an article entitled Factors that Influence the Selection of a Condenser, to the September 5 issue of *Power*.

JOHN H. BERNHARD delivered a lantern slide talk on River Craft and River Terminals at the September 13 meeting of The Engineers' Club of St. Louis.

DAVID B. RUSHMORE delivered a lecture on The Nitrogen Industry as a Power Load, at the 37th annual convention of the Association of Edison Illuminating Companies, held at Hot Springs, Va.

DABNEY H. MAURY is joint author with R. E. Horton of a brief article entitled Old Brick Intake Tunnel Shows Low Kutter Factor, which appears in the September 7 number of *Engineering News*.

WILLIAM G. HOUSKEEPER presented a paper on Probability Curves as Applied to Photometric Measurements, at the tenth annual convention of the Illuminating Engineering Society, held in Philadelphia, Pa., September 18 to 20.

ROBERT THURSTON KENT, consulting engineer, is the author of a new book on Power Transmission by Leather Belting. This is one of a new Wiley engineering series in which each book will be devoted to a single subject of engineering practice.

OBERLIN SMITH is the author of Pressing and Stamping Metals, which appears in the September issue of *The Engineering Magazine*. This is the first of a series of articles reviewing the more recent developments and processes in this field.

Among the papers presented at the September 14 to 16 convention of the National Association of Cotton Manufacturers held at New London, Conn., were: Individual Caution the Most Effective Accident Preventive, M. W. ALEXANDER; Presentation of the Proposed Plan for Enlarging the Scope of the Association, ALBERT G. DUNCAN; The Moisture Conditioning of Cotton with Relation to Picker Fires, F. J. HOXIE.

NECROLOGY

FRANK BARTLETT McSOLEY

Frank Bartlett McSoley was born at Providence, R. I., on December 11, 1885. He received his early education in the common schools and was graduated from the Providence Technical High School, where he took a special mechanical, electrical and steam engineering course. He was also graduated from the Rhode Island School of Design, where he specialized in mechanical and steam design.

In 1905 Mr. McSoley entered the service of the Narragansett Electric Lighting Company of Providence, where he had full charge of the service department and of output computation of generating and sub-stations, also the estimating of construction and extension costs. He was, in addition, personal assistant to the General Manager.

He was much interested in wireless telegraphy, and delivered a number of lectures on this subject. He organized the Rhode Island Wireless Telegraphic Association, of which he was first president. He was later made chairman of the advisory board of the association.

Mr. McSoley was a member of the National Electric Light Association, the American Institute of Electrical Engineers, and The Institute of Radio Engineers. He became a member of the Society in 1911. He was also very active in the Boy Scout Movement. He died at his home in Providence on August 15, 1916.

WILLIAM BAYLY UPTON

William Bayly Upton was born in San Francisco, Cal., on October 30, 1856. He received his education in the home schools and served his apprenticeship at the Union Iron Works in San Francisco. Up to 1892, he was associated with cable road construction in San Francisco and Kansas City, when he was called to Washington, D. C., for similar work with the Capital Traction Company. He served later as engineer in charge of the construction of several of the important underground and overhead electric lines now under the control of the Washington Railway & Electric Company, and was engineer in charge of the joint construction by the two traction companies of the lines approaching the Union Station. Among other of his achievements in Washington was the planning and installation of the lighting and wiring system in the Municipal Filtration Plant. He recently returned to San Francisco to take charge of the construction of the Argentine Pavilion at the Panama-Pacific International Exposition, 1915.

Mr. Upton became a member of the Society in 1894. He died in Alameda, Cal., on July 30, 1916.

EMPLOYMENT BULLETIN

THE Secretary considers it a special obligation and pleasant duty to make the office of the Society the medium for assisting members to secure positions, by putting them in touch with special opportunities for which their training and experience qualify them, and for helping anyone desiring engineering services. The Society acts only as a clearing house in these matters.

POSITIONS AVAILABLE

In forwarding applications, stamps should be enclosed for transmittal to advertisers; applications from non-members should be accompanied by a letter of reference or introduction from a member, such reference letter to be filed by the Society. Copy for notices should be in hand by the 18th of the month.

DESIGNER, on heavy machine tools and similar machinery; good opportunity for high-grade man with chiefly drawing-office experience. Location Pennsylvania. 40

SALESMAN with technical education as mechanical engineer to become head salesman of company manufacturing heavy-capacity automatic scales for factory and warehouse uses. Man between 30 and 40; must be master salesman. Broad selling experience absolutely essential; educational requirement secondary. 42

DRAFTSMAN experienced in heavy machinery, and, if possible, on chemical apparatus. Salary $25-$30. Location New Jersey. 50

ASSISTANT CHIEF ENGINEER. Young man who has had experience in or made special study of power plant operation, to assist in running woodworking factory of 1000 h.p. Knowledge of design of exhaust steam heating on large scale desirable. Answer, stating age, past positions and salary expected. 83

DRAFTSMAN, experienced in design of heavy machinery, rolling mills, etc. Location Connecticut. 98

RECENT GRADUATES in mechanical engineering from schools of recognized standing, desired for testing work in large steam-operated electric power plants. Applicants with experience in testing work will be given preference. State particulars of education, experience and salary desired. 167

TOOL DESIGNER who is resourceful and can follow work through to completion. Technical man with practical shop experience. Salary $25 to $35 per week according to ability. Location Connecticut. 185

MECHANICAL ENGINEER to take charge of research department in development and manufacture of underfeed mechanical stokers. Experienced in designing, construction and operation. Good opportunity for right man. Old established corporation. State age, experience, when at liberty, salary expected, etc. Location Middle West. Apply by letter. 238

ASSISTANT in mechanical laboratories in eastern technical school at least a year out of college, with some practical experience in the care and handling of mechanical equipment. Give full details of education, practical experience and references. Wanted for present college year. Location near New York. 366

DRAFTSMEN familiar with design of piping and layout and equipment for power plants. State training, experience and salary expected. Location New England. 379

INDUSTRIAL ENGINEER, 22 to 25 years of age, with knowledge of cane sugar house work and experience in drafting department, for concern of consulting and contracting engineers, sugar factories and equipment, marine work, etc. Location New York. 387

EXPERIENCED MAN on twist drills, one thoroughly familiar with twist-drill-making machines and able to help on the design for new factory, to have charge of this department as soon as started. 413

YOUNG ENGINEER who has had some shop experience and has the ability to develop into an executive. Location New York. 495

SUPERINTENDENT for small plant to take general charge of operations of textile-treating industry in fire- and water-proofing as well as dyeing piece goods. Some one preferred with knowledge of dyeing, especially with logwood. Location New York State. 505

DRAFTSMAN. Opening for capable draftsman, experienced in conveying machinery. Good opportunity with splendid chance of advancement to proper party. In reply, state experience, references, age and salary expected. Location Middle West. Communications treated confidentially. 507

YOUNG ENGINEER for tractor factory. Position offers exceptional opportunity to energetic man. 510

FOUNDRY FOREMAN. Would have charge of about 60 molders, making gray iron and semi-steel castings for gas engines, steam engines and separators. Total number of men employed will run as high as 120 during some seasons; this includes men in core room, cleaning room, etc. Prefer a man with experience in agricultural machinery. Must have ability to handle men, and a record showing thorough experience in foundry lines. Salary determined by previous experience and qualifications. Location Ohio. 511

ASSISTANT WORKS MANAGER and FOUNDRY SUPERINTENDENT, to be combined in one position provided man can be found with ability and experience, well acquainted with machine shop practice and up-to-date in foundry management; or two positions will be created, one of Assistant Works Manager, the other Foundry Superintendent. Company manufactures power specialties. Location Pittsburgh. 512-513

ENGINEER with experience to become member of staff being organized for design and construction of new metallurgical plant. Location New Jersey. 521

INVESTMENT of $20,000 to $25,000 and practical working interest in business near Philadelphia, engaged in operation on a limited scale for making silica brick. Present owner desires capable assistant in running well-established business. 522

SHOP INSTRUCTOR for foundry work and forging. Would like man who is industrious and thoroughgoing, would get along well with students and be anxious to improve his department. Good equipment in each line of work, and ample opportunity for man to conduct special investigations. Salary $1200. Location Nebraska. 523

CHECKER, SQUAD-BOSS AND DRAFTSMAN, experienced in industrial engineering, wanted by large Eastern smelting company. State age, education, experience and salary desired in first letter. Permanent positions to capable men. 524

DRAFTSMAN, capable of designing large machines for boring and milling; also to design fixtures and tools for use on such machines, to hold and perform work shown by drawings. Location Providence. 525

YOUNG MECHANICAL ENGINEER for concern on Long Island building automobiles; man of unusual ability and broad calibre desired, who will develop in this work. Past experience in automobiles not necessarily essential. 528

ENGINEER, experienced in machine design, for executive position in experimental department of large industrial concern. Chemical knowledge helpful. Permanent position with attractive future. Advise experience and salary expected. 529

CHEMICAL ENGINEER, experienced in aniline dye manufacturing, to become department engineer; $40 to $60 per week, depending upon ability. Name confidential. Location New York State. 530

YOUNG MECHANICAL ENGINEER on design and building of pumping stations. Technical graduate preferred. Salary $1800 to $2100. Location Brooklyn, N. Y. 531

YOUNG COLLEGE GRADUATE in electrical or mechanical engineering (preferably electrical) with some experience in purchasing, estimating or contracting, and some practical business experience in connection with steam-engine and hydraulic work or gas business would be most serviceable. Location Boston. 534

GENERAL SUPERINTENDENT for modern manufacturing plant in Middle West. Large gas engines, steam engines and heavy special machinery principal products. Successful experience in shop management and practical knowledge of modern foundry and machine shop methods required. Town of 12,000. Desirable living conditions. Apply first by letter. 535

MECHANICAL DRAFTSMAN for general power plant work. Salary $125. 538

PLANT ENGINEER for up-to-date electrical plant of 5,000 employees. Address, giving age, weight, height, experience, salary expected and references in first letter. Location Middle West. 541

YOUNG ENGINEER, preferably class of '16, to start in testing department of machinery concern building pumps, turbines and condensers. Location fifty miles from New York City. 542

MECHANICAL ENGINEER, with experience in petroleum refining. Position calls for work in Mexico. Preference to applicants who are

single and have had training in European country. State experience and education. 543

FOREMAN, competent to run shop making castings and forgings. Employ upwards of 200 men. Man of some education and who knows how to handle men and get work done. Hours from 7 to 5.30. Location Middle West. 545

DESIGNING DRAFTSMAN, familiar with cam motions and gears. Location New York State. 546

HIGH-GRADE EXPERIENCED MAN to do rate-setting and time-study work and take general charge of efficiency work of machine shop. Require man who has had actual experience along these lines and who has made good. Technical graduate desirable, but not essential. Prefer man over 30 years of age. Location Massachusetts. 547

DESIGNERS and DRAFTSMEN with experience in design and construction of crude oil engines, two- and four-cycle, stationary and marine type. Give particulars of salary expected, previous experience, etc. Location Maryland. Apply by letter. 548

GENERAL SUPERINTENDENT in munitions and later in electrical factory. Salary $3600. Location New Jersey. 552

MACHINERY SALESMAN experienced in obtaining work for a contract shop. Location Boston. 556

YOUNG ENGINEER, with technical education and special training in design of automatic machinery for manufacture of small interchangeable parts. Excellent chance for advancement to one who displays ability and application. Location Chicago. 139

DESIGNER for special machinery and labor-saving devices, capable of following work through shop to completion. Location New York State. 248

SALESMAN. Man having experience in tool steel and alloy steels preferred. Opportunity for advancement. State age, experience and salary expected. Location New York. 360

ENGINEER AND DESIGNER, with experience either in forging and die pressing of brass or die casting machines. Must be capable of making investigations of materials, methods of manufacture, etc., and work out principles of design of necessary equipment. New lines of work in large manufacturing concern in middle west and excellent opportunity for men who have originality and initiative. 554

ASSISTANT in mechanical engineering, University of Idaho; mechanical engineering graduate; send photograph, full record of experience and credentials in first letter. Compensation $800 for nine months, from September 15 to June 15, 1917. 555

MEN AVAILABLE

Only members of the Society are listed in the published notices in this section. Copy for notices should be in hand by the 18th of the month, and the form of the notice should be such that the initial words indicate the classification. Notices are not repeated in consecutive issues.

SALESMAN, SALES ENGINEER. Associate-Member, age 35. American born, single, technically educated. Fifteen years' wide experience as designing and structural engineer in 10 cities of U. S. and 3 foreign countries. Now in Canada. Pleasing personality, especially adapted for dealings with foreigners. Must leave responsible work at $200 a month on account of eye strain. Will start for $100 a month with large firm as traveling salesman. Some selling experience and many references. J-327

EXECUTIVE ENGINEERING or SALES. Technical graduate. Familiar with sale of oils and handling by pipe lines, motor trucks and ships. Able to design and install pipe lines, power-plant equipment, tanks, etc. Capable of handling accounts and cutting costs. Several years experience in conducting efficiency tests of power-plant equipment, lubricants, air compressors and shop material. Initial salary a secondary consideration. Can handle men without friction and obtain results. J-328

ADMINISTRATIVE or EXECUTIVE position. Member, with electrical, mechanical and commercial training. Experience includes electric-traction projects; design and construction of manufacturing plants; design of factory product, machine-tool operations, cost and general accounting; systematizing of shop, office and drawing room; familiarity with efficient management methods, production control, etc. Has just completed important electrical installation and desires to obtain permanent and responsible position with a manufacturing or industrial plant. Central New York preferred. J-329

ENGINEERING, EXECUTIVE or confidential position by a man just completing a standardization proposition. Experienced theoretically and practically. Would consider connecting with a new enterprise, development or installation of a new project or system, or taking charge of the engineering or confidential interests of an individual or corporation. Best of references as to ability, standing, etc. Willing to go anywhere. J-330

MECHANICAL SUPERINTENDENT or MASTER MECHANIC. Associate-Member, age 32, technical graduate. Eight years experience in construction and repairs. Available at once. J-331

MANAGER, WORKS MANAGER or GENERAL SUPERINTENDENT. Technical education, M. E. Good executive abilities, thorough in modern methods and practices, japanning, wood-working, etc. Over 25 years broad and varied experience in heavy, medium, small and interchangeable work (electrical and metal-working). Practical mechanic. Thoroughly capable in shop organization and supervision of manufacturing, qualified in office, buying, sales, cost, piece, bonus or premium methods. J-332

ENGINEER-SALESMAN, capable of approaching with confidence architects and engineers or owners on larger construction operations in New York or New England and nearby states for concern desiring new business or development of special department. J-333

MECHANICAL ENGINEER of large experience as executive, sales representative and designer would like to communicate with concerns appreciating conscientious work for substantial results. Machine tools or special machinery preferred. J-334

ENGINEER-EXECUTIVE. Member. Fourteen years experience, eight years in charge. Any location in U. S. J-335

SALES MANAGER. Member, age 38. Successful, reliable salesman and practical mechanic with unusual business training. At present connected with sales force of prominent eastern jobbers. Seven years as department sales manager. Qualified to represent manufacturers of steel products, machinery, hardware or kindred lines; would consider group of non-conflicting lines. Fully conversant with Spanish language and the Latin people; diplomatic, forceful and energetic. Wishes to correspond with firms desiring to extend their field in manufacturing lines suited to South American trade. Open for engagement in South America or Spain. Nominal initial salary. J-336

CHECKER. Experienced man, able to take charge of design on any line of steam goods, particularly valves and fittings. J-337

SUPERINTENDENT or CHIEF DRAFTSMAN. Member, age 38. Mechanical engineer, 14 years drawing-room and 6 years shop experience on steam and combustion engines, hydraulic machinery, tools, etc. Expert designer of molds for shellac and pyroxylin compounds and phenol condensation materials. Desires position in vicinity of Newark, N. J. Salary $2000. J-338

GENERAL MANAGER or CHIEF ENGINEER. Age 40, technical training. 15 years experience on hoisting machinery, contractors plant, dredges, locomotive cranes, etc. Has successfully held positions as designer, chief draftsman, chief engineer and general manager. J-339

ASSISTANT MANAGER or SUPERINTENDENT. Associate-Member, age 30. Technical graduate with shop training. Broad experience in design and engineering work; familiar with costs, production and modern business methods. J-340

ASSISTANT CHIEF ENGINEER or ASSISTANT SUPERINTENDENT of manufacturing plant. Columbia M. E., age 32. About ten years experience, embracing design of coal- and ore-handling machinery, railway electrification and acid plants. Practical experience in shops before entering college. Has been assistant chief engineer on acid plants and assistant superintendent in charge of maintenance, repair and construction of industrial plants. J-341

SALES MANAGER. Member, with exceptional experience and record. Familiar with electrical and mechanical power equipment from coal pile to shipping room. Draws the line between system and red tape and gets results. Wants larger field, responsibilities and compensation than possible in present position. J-342

MECHANICAL ENGINEER. Member, age 33. Specialty: design and erection of shops and power plants, including selection and installation of equipment. J-343

MECHANICAL ENGINEER. Twenty years experience in the practical management of power-plant equipments; 15 years as an executive. Has had broad experience with steam, electrical, hydraulic and refrigerating machinery. At present chief engineer and superintendent of maintenance of large industrial plant. Would like to connect with large concern desiring to improve their conditions. No position considered below $2500. J-344

FACTORY MANAGER. Technical graduate, M. E., age 30. Ten years experience in costs, efficiency engineering and factory management. Can refer to several successful concerns as to ability and results secured in increased output and decreased costs. Desires position as manager of plant where compensation will be in proportion to results obtained. J-345

ASSISTANT SUPERINTENDENT. Technical graduate. Four years manufacturing experience. Thoroughly familiar with modern methods of cost accounting, production and management. References furnished. Location, Middle West preferred. Salary $125. J-346

MECHANICAL ENGINEER. Columbia graduate. Eighteen months experience as machinist, draftsman, inspector, also head inspector in power-plant-testing work. Desires position in or near New York City with manufacturing or engineering concern. J-347

SALES ENGINEER or ASSISTANT TO EXECUTIVE. Member. Eighteen years engineering experience in design, shop, sales and executive work, railroad equipment, special machinery, structural steel and power plants. At present employed as sales engineer but desires change to concern offering greater opportunities. Can report anywhere on short notice. Good working knowledge of Spanish. J-348

MECHANICAL ENGINEER, age 42. Twelve years experience in design, testing and operation of boilers and mechanical stokers. Now employed in executive capacity. Desires position with boiler or stoker manufacturer, or with large plant as power efficiency engineer, or as sales engineer with boiler or stoker manufacturer. J-349

DRAFTSMAN. 1914 M. E. graduate from University of Illinois desires position as power-plant draftsman. Location preferably Chicago. J-350

MECHANICAL ENGINEER. Technical graduate. Two years experience in handling labor and in scientific management work. Desires change in location and a permanent position. J-351

MECHANICAL ENGINEER. Cornell graduate. Extended experience in designing, constructing and installing large, small and special machine tools. Has held positions as chief engineer and manager while engaged in the sale, design and manufacture of high-duty pumping engines, condensers, large air and gas compressors and special machine tools. Willing to take stock for part salary if desired. J-352

TECHNICAL GRADUATE. Four years apprenticeship in railroad shops, seven years drafting-room experience, twenty-one months in charge of construction work. Desires position where shop and executive experience will be of value to employer. J-353

CHIEF DRAFTSMAN, CHIEF ENGINEER or MASTER MECHANIC. Fifteen years experience in quantity manufacture, automatic machinery, factory maintenance, experimenting, etc. Available October 1. Salary $2600. J-354

DIRECTOR OR INSTRUCTOR. Member. Technical education and over twenty years practical experience. At present superintendent of industrial school. Desires position in vocational or industrial school, Eastern part of United States preferred. Salary $1800. J-355

SUPERINTENDENT or ASSISTANT MANAGER. Twenty years' experience on large variety of machine work. At present superintendent in a large plant. Desires position with machinery manufacturing concern. New England preferred. J-356

MECHANICAL or CHIEF ENGINEER. Graduate M. E., age 35, experience as superintendent of erection and operating engineer of power plants. Master mechanic of large factory. Last six years chief engineer in charge design, construction and maintenance of engineering work, including city light and water departments. Good executive ability. Capable of assuming responsibility and handling men. J-357.

MEMBER. Graduate of U. S. Naval Academy, age 33, married. Tactful and able organizer and manager of manufacturing propositions. Large experience in executive positions, particularly in public-service corporations and munitions work. J-358

JUNIOR MEMBER. Age 27, experienced in building construction. Has been associated with big New York builder for six years, for whom he is now acting as purchasing agent and in executive capacity. Can design heating and electrical systems, write specifications, award subcontracts and supervise construction. Desires connection with industrial concern doing its own building or with general contractor. J-359

MEMBER of the A.S.M.E. and A.I.E.E. College and technical graduate. 18 years broad experience in design, construction and operation of power plants, substations, motor applications and high-tension transmission. Has proven executive ability, good correspondent, adaptable, systematic and reliable. Desires position, subordinate or otherwise, preferably in or near New York. J-360

MANUFACTURERS' REPRESENTATIVE. Mechanical engineer. Excellent business training and experience particularly in prime movers, boilers and power plant equipment. Desires to represent manufacturers in New York City, preferably on commission basis. English, German and French correspondent. J-361

MECHANICAL ENGINEER in New York City holding very responsible position, desires an additional position on half time in same city or vicinity. M.E. graduate. Five years experience in economic plant engineering. Possesses initiative and thoroughness. J-362

ACCESSIONS TO THE LIBRARY

A List of Books and Pamphlets Added During the Past Month to the Library of the Society and of the United Engineering Society, Engineering Societies Building, New York

ADDITIONS BY THE SOCIETY

AMERICAN SOCIETY OF MECHANICAL ENGINEERS. Power Test Code. Rules for conducting performance tests of power plant apparatus. 1915. Gift of Society.

——— Report of the Committee to Formulate Standard Specifications for the Construction of Steam Boilers and other pressure vessels and for their care in service, known as The Boiler Code Committee. 1914. Gift of Society.

EFFICIENCY AND LIFE, E. E. Purinton, with introduction by Melvil Dewey. *New York, 1916.* Gift of A. S. M. E.

THE FLOW OF AIR THRU NOZZLES AND ORIFICES. A Thesis presented to the Department of Mechanical Engineering, Leland Stanford Jr. University by J. L. Reynolds and Homer J. Ling. Gift of Homer J. Ling.

NORMAL LOSSES OCCURRING IN EVERY INDUSTRY, Frederic Schreibman. Gift of author.

ST. LOUIS PUBLIC LIBRARY. Annual Report, 1915-16. *St. Louis, 1916.* Gift of Public Library.

SMOKE PREVENTION ASSOCIATION (Chicago). Proceedings, 10th Annual Convention. *Chicago, 1915.* Gift of Smoke Prevention Association.

EXCHANGES

U. S. PATENT OFFICE. Annual Report of the Commissioner of Patents, 1915. *Washington, 1916.*

TRADE CATALOGUES

BRIDGEPORT ENGINEERING CO. *Bridgeport, Conn.* Woodworking tools. Descriptive catalogue.

DIAMOND POWER SPECIALTY CO. *Detroit, Mich.* Power Notes. *July, 1916.* Bulletin 118. Insuluminum. *July 1, 1916.*

LESCHEN, A., & SONS, ROPE CO. *St. Louis, Mo.* Leschen's Hercules. *Aug. 1916.*

STEPHENS-ADAMSON MFG. CO. *Aurora, Ill.* Labor Saver. *Aug., 1916.*

ADDITIONS BY THE UNITED ENGINEERING SOCIETY

THE ADELONG GOLDFIELD. New South Wales. Department of Mines. Mineral Resources, no. 21. *Sydney, 1916.*

AMERICAN FERTILIZER HANDBOOK, 1916. *Philadelphia, Ware Bros. Company, 1916.* Gift of the publishers.

AMERICAN SOCIETY FOR TESTING MATERIALS. Membership List, 1916. *Philadelphia, 1916.*

COALS OF LETCHER COUNTY. Kentucky Geological Survey. Ser. IV, vol. 4, pt. 1. *Frankfort, 1916.*

CONSTRUCTION AND OPERATION OF A SINGLE TUBE CRACKING FURNACE FOR MAKING GASOLINE. U. S. Bureau of Mines Technical Paper 161. *Washington, 1916.*

EMISSION OF ELECTRICITY FROM HOT BODIES, O. W. Richardson. *London, 1916.*

FINANCING THE CITY OF NEW YORK. Two lectures by Wm. A. Prendergast, Comptroller, delivered March 14, 28, 1916. Gift of New York City Dept. of Finance.

GEOLOGICAL SOCIETY OF LONDON. List of Members, July, 1916. *London, 1916.*

GEOLOGY OF THE SHAWNEETOWN QUADRANGLE IN KENTUCKY. Kentucky Geological Survey. *Frankfort, 1916.*

HEAT TREATMENT OF TOOL STEEL, Harry Brearley. ed. 2. *New York, 1916.*

HEBEKRANE. A. S. Ratnovski. Vol. I, pt. 1-3; vol. II, pt. 1. *Petrograd, 1910, 1912, 1915.*

INSTITUTE OF METALS. Journal, vol. XV. *London, 1916.*

INSTITUTION OF MECHANICAL ENGINEERS. Proceedings. January-May 1916. *London, 1916.*

INTRODUCTION TO THE THEORY AND PRACTICE OF BOOT AND SHOE MANUFACTURE, Frank Plucknett. *London, 1916.*

KUNGL. TEKNISKA HÖGSKOLAN I STOCKHOLM. Program 1916-17. *Stockholm, 1916.* Gift of Kungl. Tekniska Högskolan I Stockholm.

MANUFACTURE OF CHEMICAL MANURES, J. Fritsch, translated from the French by Donald Grant. *London, 1911.*

McGRAW ELECTRIC RAILWAY LIST, August, 1916. *New York, 1916.*

MESOZOIC AND TERTIARY INSECTS OF QUEENSLAND AND SOUTH WALES. Queensland. Department of Mines. Publication no. 253. *Brisbane, 1916.*

METHODS OF SAMPLING DELIVERED COAL. U. S. Bureau of Mines. Bulletin 116. *Washington, 1916.*

MOTOR CYLINDER LUBRICATION, Lieut G. S. Bryan. Reprinted from Jour. Amer. Soc. of Naval Engineers, vol. 27, Feb., 1915. Gift of The Texas Company.

NEBRASKA STATE RAILWAY COMMISSION. 8th Annual Report. *Lincoln, 1915.* Gift of Commission.

THE NEW ANACONDA. July, 1916. *New York, Eugene Meyer, Jr. & Co., 1916.* Gift of publisher.

NEW ENGLAND WATER WORKS ASSOCIATION. Index, Transactions 1883-1885. Journal volumes I-XXIX. *Boston, 1916.*

NEW YORK TIMES INDEX. Vol. IV, April-June, 1916. *New York, 1916.*

NOTES ON SCREW GAUGES. National Physical Laboratory. Feb., 1916. *London, 1916.*

PENNSYLVANIA. DEPARTMENT OF FORESTRY. Report of the Chief Forest Fire Warden for the year 1915. Bulletin 13. *Harrisburg, 1916.*

PENNSYLVANIA. DEPARTMENT OF INTERNAL AFFAIRS. Part IV. Railroad, Canal, Navigation, Telegraph and Telephone Companies. 1915. *Harrisburg, 1916.*

PETROLEUM PROSPECTS ON BRUNY ISLAND. *Tasmania, 1916.* Report by Arthur Wade.

PRACTICAL LUBRICATION, Lieut. G. S. Bryan. Reprinted from Jour. Amer. Soc. of Naval Engineers, vol. 27, Nov. 1915. Gift of The Texas Company.

PREPAREDNESS FOR AERIAL DEFENSE, Alexander Graham Bell. Address delivered before the National Convention of the Navy League of the United States. April 10-13, 1916. Gift of author.

PRODUCTION OF EXPLOSIVES IN THE UNITED STATES DURING THE CALENDAR YEAR 1915. U. S. Bureau of Mines. Technical Paper 159. *Washington, 1916.*

PUBLIC UTILITIES PROFESSIONAL REFERENCE LIST. First Issue. *Rochester, 1916.* Gift of Lawyers Co-operative Publishing Co.

PUBLIC UTILITIES REPORTS. 1916-C. *Rochester, 1916.*

THE RAILWAY LIBRARY AND STATISTICS, 1915. Compiled by Slason Thompson. *Chicago, 1916.* Gift of Slason Thompson.

RAPPORT SUR LES GISEMENTS DE CUIVRE DES CANTONS DE L'EST DE LA PROVINCE DE QUÉBEC, J. A. Bancroft. *Quebec, 1916.*

SECOND GOOD ROADS INSTITUTE. Proceedings, Held at the University of North Carolina, Feb. 23-27, 1915. Economic Paper 43, North Carolina Geological and Economic Survey. *Raleigh, 1916.*

SENSITIVENESS TO DETONATION OF TRINITROTOLUENE AND TETRANITROMETHYLANILIN. Technical Paper 145, U. S. Bureau of Mines. *Washington, 1915.*

SESSILE BARNACLES (CIRRIPEDIA) CONTAINED IN THE COLLECTIONS OF THE U. S. NATIONAL MUSEUM, INCLUDING A MONOGRAPH OF THE AMERICAN SPECIES. U. S. National Museum. Bulletin 93. *Washington, 1916.*

SILVER CITY, NEW MEXICO. U. S. Geological Survey, Folio 199. *Washington, 1916.*

SOURCES OF NITROGEN COMPOUNDS IN THE UNITED STATES. Publication 2421, Smithsonian Institution. *Washington, 1916.*

THE SOUTH HEMMSKIRK TIN FIELD, WITH MAPS. Tasmania. Geological Survey. Bulletin no. 21. *Tasmania, 1916.*

SPIRIT LEVELING IN WEST VIRGINIA. U. S. Geological Survey. Bulletin 632. *Washington, 1916.*

SPUR GEARING, Daniel Adamson. Excerpt Minutes of Proceedings of Institution of Mechanical Engineers, May 19 and 23, 1916. *London, 1916.* Gift of author.

SVENSKA TEKNOLOGFÖRENINGEN. Ledamotsförteckning. July, 1916. *Stockholm, 1916.*

TABLE OF THE EIGHTY-FOUR RESEARCH PAPERS AND SCIENTIFIC ADDRESSES BY SIR ROBERT HADFIELD, 1888-1912. Gift of Sir Robert Hadfield.

TARIFF SYSTEMS OF SOUTH AMERICAN COUNTRIES, F. R. Rutter. U. S. Dept. of Commerce, tariff series, no. 34. *Washington, 1916.*

TECHNOLOGY OF MARBLE QUARRYING. U. S. Bureau of Mines. Bulletin 106. *Washington, 1916.*

THEORY AND CALCULATION OF ALTERNATING CURRENT PHENOMENA, C. P. Steinmetz. ed. 5. *New York, 1916.*

THEORY AND EXPERIMENTS IN FOLLOWING PLANE MACHINES, Chas. R. Witteman. Presented at a meeting of Aeronautical Society, June 3, 1915. Gift of Aeronautical Society.

TRAINING OF OUR CAPTAINS OF INDUSTRY, Sir Robert Hadfield. Reprinted from Iron & Coal Trades Review, June 9, 1916. Gift of Sir Robert Hadfield.

TRAITÉ DE LA MÉCANIQUE DES CORPS SOLIDES ET DU CALCUL DE L'EFFET DES MACHINES, G. Coriolis. ed. 2. *Paris, 1844.*

TRAITÉ DES MACHINES-OUTILS, Gustave Richard. 2 vols. *Paris, 1895, 1896.*

U. S. BUREAU OF THE CENSUS. Census of manufactures: 1914. Power Laundries. *Washington, 1916.*

VANADIUM STEELS—THEIR RELATION TO MACHINE DESIGN. Aeronautical Society, Bulletin, July 27, 1911. Gift of Aeronautical Society.

VAN DEPOELE ELECTRIC MANUFACTURING COMPANY, manufacturers of dynamo electric machines, arc and incandescent lamps, electric motors and electro-plating machines. Chicago. Gift of T. C. Martin.

VIRGINIA—Report of the progress of the Geological Survey. 1839. *Richmond, 1840.*

WEST VIRGINIA GEOLOGICAL SURVEY. Raleigh County and the Western Portions of Mercer and Summers Counties, with maps. *Wheeling, 1916.*

WHO'S WHO IN AMERICA. vol. IX, 1916-1917. *Chicago, 1916.*

DIE WIRKUNGSWEISE DER REKTIFIZER UND DESTILLIER APPARATE, E. Hausbrand. ed. 3. *Berlin, 1916.*

WIRELESS TELEGRAPHY, J. Zenneck. *New York, 1915.*

WIRTSCHAFTLICHE VERWERTUNG DER BRENNSTOFFE, G. de Grahl. *Munchen, 1915.*

THE WOLFRAM, MOLYBDENITE AND BISMUTH MINES OF BAMFORD, NORTH QUEENSLAND. Queensland Geological Survey. Publication 248. *Brisbane, 1915.*

YEAR BOOK OF PHOTOGRAPHY. 1871, 1891. Gift of Arthur Worischek.

ZIRCON, MONAZITE AND OTHER MINERALS USED IN THE PRODUCTION OF CHEMICAL COMPOUNDS EMPLOYED IN THE MANUFACTURE OF LIGHTING APPARATUS. Bulletin no. 25, North Carolina Geological and Economic Survey. *Raleigh, 1916.*

ZOOLOGY OF MICHIGAN. Publication 20, biological Ser. 4, Michigan Geological and Biological Survey. *Lansing, 1916.*

GIFT OF BUREAU OF RAILWAY ECONOMICS

ACCIDENTS AT GRADE CROSSINGS AND TO TRESPASSERS. Address by Alex. Gordon.

COÖPERATING WITH FARMERS. A paper read by G. E. Cassel, May 14, 1915.

FAILURE OF GOVERNMENT OWNERSHIP IN CANADA, S. O. Dunn. Reprinted from Journal of Political Economy, June, 1916.

LOCAL FREIGHT AGENT. An address before the American Association of Freight Agents, by Fairfax Harrison, June 20, 1916.

NEW LONDON SITUATION AND LABOR PROBLEMS, H. Elliott. Address to the Chamber of Commerce of New London, Conn., April 12, 1916.

SOME DIFFICULTIES OF THE TRANSPORTATION BUSINESS, H. Elliott. Address to the Chamber of Commerce of Ansonia, Conn., April 4, 1916.

SOUTH AND THE SOUTHERN RAILWAY. The statement of a record and of an ambition. An address before the Virginia Bankers' Association, by Fairfax Harrison, June 23, 1916.

VALUE OF CO-OPERATION, H. Elliott. Address at the 50th anniversary of the Organization of the Y. M. C. A., New Haven, Conn., April 3, 1916.

RAILWAYS AS A PART OF A SYSTEM OF NATIONAL DEFENSE. An address by W. L. Park. Read before the International Association of Railway Special Agents and Police, New Orleans, May 25, 1916.

REMARKS AT MIDDLEBURY COLLEGE ON COMMENCEMENT, Howard Elliott, June 21, 1916.

UNDER FORTY-NINE MASTERS, Francis H. Sisson. Reprinted from Moody's Magazine, June, 1916.

GIFT OF F. H. COLVIN

A collection of various numbers of Journal of The Franklin Institute; American Engineer and Railroad Journal; New York Railroad Club; Locomotive Engineer and Locomotive Engineering.

ENGINEERING SURVEY

A Review of Engineering Publications in All Languages. All the leading periodicals of the engineering world, embracing over 1000 different publications, are received at the Library. These are systematically examined for review each month in the Survey.

SUBJECTS OF ABSTRACTS

ARRANGED IN THE ORDER OF THEIR APPEARANCE IN THE SURVEY.

HIGH-SPEED CENTRIFUGAL BLOWER.
TURBO-COMPRESSOR.
INVAR.
NICKEL STEELS.
COPPER-CLAD STEEL WIRE.
RUBBER VULCANIZATION ACCELERATORS.
COPPER, ANNEALING PROPERTIES.
SILVER IN COPPER AS AN IMPURITY.
COLD-ROLLING STRIP STEEL.
CONCRETE, EFFECT OF SUGAR ON.
CHAIN SCREEN DOORS.
OIL-BURNING WITH NATURAL DRAFT.
WASTE MOLDING SAND, RECLAIMING.
PIPE CASTING, CENTRIFUGAL MACHINE FOR.
WASTE FOUNDRY SAND.
ALUMINUM CASTINGS AND FORGINGS.
ALUMINUM-MANGANESE ALLOYS.
WOOD PIPES.
KEROSENE ENGINE, MACLAREN MARINE.
CARBURETER, KEROSENE-GASOLINE.
BLOWLAMP HEATING FOR STARTING ON KEROSENE.
WASTE HEAT SAVING BY THERMO-COUPLES.
GAS ENGINE WITH WASTE-HEAT SAVING.
MERIAM SYSTEM OF COOLING ON LARGE GAS ENGINE.
ENGINE, TWO-CRANK, FOUR-CYLINDER.
HIGH ELEVATION AND DIESEL ENGINE WORKING.
BURRO MOUNTAIN COPPER COMPANY'S PLANT.
SCREW THREADS, I. S. SYSTEM.
FRENCH ARTILLERY ADOPTS I. S. THREAD.
FRICTION CLUTCHES.
SKEW BEVEL GEARS.
VENTURI METERS ON LIVELY LINES.
TRACK SCALE, HEAVY.
SHRAPNEL FUSE BODIES, RECLAIMING.
PILE EXTRACTOR.
PUMP, MERCURY HIGH-VACUUM HIGH-SPEED.
PUMP, CENTRIFUGAL, CASING.
ICE, RAW-WATER CAN.
BOILER ROOMS ON WARSHIPS, AIR SUPPLY.
EVAPORATORS, TUBES FOR.
SUPERHEATERS.
SCREWDRIVERS, TESTING OF.

A good test of engineering achievement is a machine running at extremely high speeds. A speed of some thirty to sixty thousand revolutions per minute tries out in a most searching manner the design, the strength of the parts, the material used, and the balancing of a machine. From this point of view a blower running at 40,000 to 60,000 is worthy of notice. A description of it will be found in the section Air Engineering.

THIS MONTH'S ARTICLES

A turbo compressor built in England is described.

Data from a publication of the U. S. Bureau of Standards are reported on Invar, a nickel steel remarkable for its extremely small thermal expansion at ordinary temperature.

Methods of production of copper-clad steel wire are abstracted from the *Electric Railway Journal*, as well as some data on its physical properties.

From an advance notice specially supplied to The Journal by the U. S. Bureau of Standards are taken data on the freezing point of mercury.

The annealing properties of copper at temperatures below 500 deg. cent. are discussed by G. V. Caesar and G. C. Gerner, Mem.Am.Soc.M.E., in a paper before the annual meeting of the American Institute of Metals. An interesting feature of this investigation is the observation made on the important influence of silver in copper, indicating that silver is quite an important impurity in electrolytic copper.

The production of cold-rolled strip steel is described in some detail.

In the section Firing and Fuel, a brief abstract is given of an article on chain screen doors. In the same section are described interesting experiments in natural draft oil burning on the *U. S. S. Fulton*. A description of a burner developed at the Fuel Oil Testing Plant, Navy Yard, Philadelphia, is included.

Two articles on waste foundry sand are abstracted in the section Foundry, where will be found also a description of a novel centrifugal machine for casting pipe. According to the statement of the inventors, they have succeeded with this machine in casting pipe which requires no further treatment except tarring.

Data on the physical properties of manganese aluminum alloys are reported from a paper by P. E. McKinney, presented at the recent annual meeting of the American Institute of Metals.

In the section Internal Combustion Engineering are reported descriptions of a marine kerosene engine using a somewhat novel type of carburetor; a large gas engine utilizing waste water-jacket heat in the form of by-product steam; a two-crank, four-cylinder combustion engine, and finally the Burro Mountain Copper Company's power plant. This latter is of interest because it uses Diesel engines at an elevation of nearly 6,000 ft.

A notice concerning the adoption of the International System Standard of screw threads by the French Artillery will be found in the section Machine Design. In the same section is presented an enumeration, with brief remarks, of some standard makes of friction clutches, as well as data on the laying out of skew bevel gears.

That venturi meters are not reliable on lively lines is the contention of Allan Hazen in an article abstracted from *Engineering News*.

From *Canadian Machinery* are taken some suggestions on reclaiming rejected Russian three-inch shrapnel fuse bodies.

A steam-driven pile extractor of novel design is described and illustrated.

In the section Pumps, particular attention is called to a high-vacuum, mercury-vapor pump of high speed, invented by an American engineer. This pump is a material improvement on the Gaede diffusion pump. An improved centrifugal pump casing is described and illustrated in the same section.

In the next section, Refrigeration, is presented some information on the high-pressure method of producing raw-water can ice, a branch of refrigeration practically created in this country and developed here exclusively.

An abstract showing an improved heat-transmitting device for evaporators is presented from a paper in the *Mechanical Engineer*.

Air Machinery

SMALL HIGH-PRESSURE CENTRIFUGAL BLOWER, Henry F. Schmidt

The blower described in this article and developed by the Westinghouse Machine Company is of interest, as it is claimed to have created the highest pressure ever obtained from a single-stage blower.

The speed selected for the blower was 43,500 r.p.m. at normal pressure, extended to 60,000 r.p.m. during the tests. Such high speeds require many interesting refinements of design. In the first place, as there is no means of transmitting the 350 to 400 h.p. required to drive the blower to a shaft running at these speeds, a small turbine had to be designed to drive the blower. In this turbine blade speeds from 1330 ft. per sec. (normal) to 1850 ft. (maximum) were used, which made it necessary to form the blades integral with the wheel,

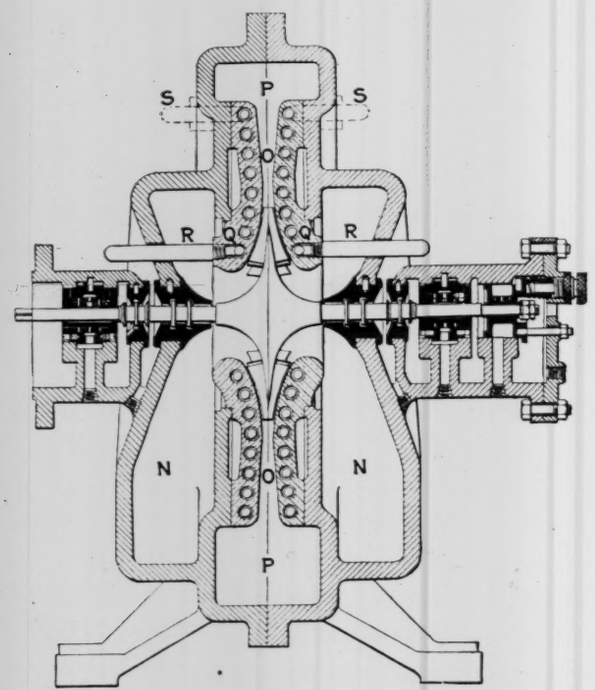

FIG. 1 CROSS-SECTION THROUGH WESTINGHOUSE HIGH-PRESSURE HIGH-SPEED CENTRIFUGAL BLOWER

since the centrifugal forces became so great that no known method of blade attachment would suffice.

For the same reasons the blower rotor had to be constructed from one forging, the blades being formed by milling out the material between them. The use of rotor tip speeds of from 1520 to 2100 ft. per sec. necessitated the use of high-grade forgings and exceptionally rigid specifications for the metal.

As an example of the enormous forces resulting at the high speeds used, it is stated that the pull on one of the blades of the blower rotor, which were only about $^1/_{16}$ in. thick by an average of $^{11}/_{16}$ in. wide and 2 in. long, amounted to a little over a ton, though the actual weight of one blade is about $^1/_{40}$ lb.

The article describes in detail the methods of production of the blower and turbine.

In the blower, Fig. 1, the air enters through the inlets *N*, which are made of the "snail" form, with a whirl chamber so as to direct the incoming air in the direction of rotation. The proportions are such that the air has the same velocity as the inside edges of the blades, thus permitting it to enter the blades without shock and tangentially instead of at an obtuse angle, as it would were the inlet not so formed.

From the inlets the air enters the blades of the rotor, is there partly compressed, and is finally discharged into the whirl chamber *O*, where the velocity is gradually reduced to less than half that with which it leaves the tips of the blades. The loss of kinetic energy reappears in the increase in pressure that occurs in the whirl chamber. Over half of the total increase in pressure occurs in the whirl chamber, the efficiency of which at the designed capacity reaches over 90 per cent of the theoretical. The whirl chamber has no guide vanes or reversed nozzles, the velocity conversion being accomplished by a free vortex the efficiency of which exceeds that obtainable by the most perfect guide vanes. This has the advantage of a high efficiency at all discharge rates, whereas the diffusion tubes or guide vanes have a good efficiency only at their designed capacity, for at all other capacities the blade angles are incorrect as well as the areas.

The cooling area exposed to the air does not appear large, but it must be remembered that with air velocities of 1500 to 2000 ft. per sec. on the outside and a water velocity of 30 to 50 ft. per sec. through the tubes, an extremely high rate of heat transfer per square foot of air surface per degree per hour can be obtained. Actually, owing to a defect in the castings for the side rings, the water cooling was not used.

TABLE 1. DATA OF TESTS OF THE WESTINGHOUSE HIGH-PRESSURE HIGH-SPEED CENTRIFUGAL BLOWER

Barometer	28.88	....	....	....	....
Steam-chest pressure	....	10	20	30	88
Air-discharge pressure	4.5*	9.1*	14.25*	18.5*	24 lb.
Temperature of discharged air, deg. fahr.	94	122	153	178	348
Rev. per min.	12,600	16,800	21,000	23,000	32,000
Vacuum	....	26 in.	26	26.5	26
Vacuum at blower nozzle throat, in. water	0.66	1.22	1.78	2.09	3.00
Adiabatic efficiency, per cent.	64	68	67.5	66	66.8
Cu. ft. of free air per min. discharged	633	860	1,040	1,130	1,360
Temperature of air at inlet nozzle, deg. fahr.	59	59	58	56	78

* These pressures are in inches of mercury.

One of the most serious problems in the design of this blower was that of getting a suitable coupling for transmitting 400 h.p. at 60,000 r.p.m. Neither attached couplings nor couplings that would require an increase in the diameter of the shaft could be used, and the old square sleeve-type coupling was employed, the squares being made $^3/_8$ in., with a 6-in. space between them. The long space between the squares made the coupling comparatively flexible, though the fit on the squares was kept down to less than 0.001 in. It was made of tool steel, oil-tempered, and was entirely satisfactory. The blower failed through the failure of the coupling to slip. An interesting point about this failure is that none of the men on test noticed anything wrong with the blower except a little smoke coming from the turbine thrust bearing.

Table 1 shows a few readings taken before the rotor was damaged, the efficiencies being those calculated from the increase of temperature of the air in passing through the blower.

The tip speed up to 20,000 r.p.m. was taken by various tachometers; beyond 20,000 r.p.m., the speed was calculated from the pressure created by the blower.

The characteristic curve of the blower shows that for a large variation of the capacity the pressure remains practically constant, and then falls off with a further increase in the delivery.

The most remarkable feature about the performance of this blower was its action with the discharge entirely shut off and with the discharge open only a small amount. At no discharge the pressure variation was surprisingly slight, and opening the discharge ever so little caused it to decrease to such an extent as to be hardly noticeable. At 2 per cent of the rating of the blower all traces of upsetting disappeared, and with water cooling all signs of upsetting would doubtless have ceased, in the opinion of the writer, at less than 1 per cent of the rating. The writer believes that this result could not have been obtained in a blower fitted with guide vanes. (*Power*, vol. 44, no. 9, p. 294, August 29, 1916, 6 p., 6 figs. *de.*)

Turbo-Compressor for a Midlands Colliery

Description of the turbo-compressor built for a large colliery in the Midlands, by the British Thomson-Houston Company, Ltd., Rugby, England.

This machine is designed to deliver 5000 cu. ft. of free air per min. at a pressure of 80 lb. per sq. in., but is capable of taking a considerable overload. While the demand varies within 30 sec. from as little as 1500 cu. ft. per min. up to its full rated capacity, the efficiency of the governing is such that the consequent change in the pressure does not exceed 2 lb. per sq. in.

The compression is effected in 13 stages grouped into two independent casings mounted in line with and driven by a Curtis steam turbine running at 4600 r.p.m. No intercooler has been provided between the two sections of the compressor casings, but each stage is carefully water-jacketed, so that the compression curve lies well below the adiabatic.

The impellers are of high-tensile steel, fitted with bronze rings in their hubs so that when forced on to their shafts the contact is between bronze and steel and not between steel and steel. This among other things makes it possible to adopt forced-fit allowances sufficient to insure that the impellers remain tight on the shaft even at the highest speeds of rotation. The large ratio of casing diameter to impeller diameter has been adopted so as to obtain more effective jacketing, and to increase the cooling effect special cast-iron blades are provided in the air passages between the stages which increase the cooling surface and also serve as guides to the fluid as it flows. (*Engineering*, vol. 102, no. 2642, p. 152, August 18, 1916, 2 pp., 3 figs. *d.*)

Engineering Materials

Invar and Related Nickel Steels

Invar is a nickel steel containing about 36 per cent nickel, together with about 0.5 per cent each of carbon and manganese. Its most remarkable property is its extremely small thermal expansion at ordinary temperatures.

The account presented by the Bureau of Standards is largely a compilation of results obtained during the last 25 years by various investigators.

The mean coefficient of linear expansion between 0 and 40 deg. cent. is of the order of one millionth for the ordinary invar, and samples have been prepared with even small negative coefficients; the amounts of carbon and manganese present appear to exercise considerable influence on the expansion. Small quantities have been manufactured with a coefficient $(+ 0.028 - 0.00232\,t)10^{-6}$, equivalent to a change in length of 0.4 mm. in 1 km. between 0 and 20 deg. cent. This was for one alloy containing 0.06 per cent carbon and 0.39 per cent manganese, the other elements being negligible. Above 200 deg. cent. the expansion of invar is nearly that of Bessemer steel.

Invar is subject to changes in length due to "after effects" following cooling from a high temperature, and to changes in length following even slight alterations in temperature. For example, at 15 deg. cent. the elongation of 1 m. is 0.07 to 0.08μ per day after forging and 0.03μ after annealing to 40 deg. cent. After a long rest at room temperature (10 to 20 deg. cent.) the contraction setting in after bringing the metal to a higher temperature is completed in about one-half hour at 100 deg. cent., and only after several days at 40 deg. cent. The range of transitory length variations following temperature changes is given approximately by the formula

$$\Delta L/L = -0.00325.10^{-6}t^2$$

which holds for temperatures between 0 and 100 deg. cent.

Invar also gradually elongates with time, forged and drawn material behaving somewhat differently in this respect, so that there is a determinable, seasonal correction to be applied to its length when used as a length standard. This effect may be reduced, but not entirely eliminated, by special heat treatments consisting in an annealing process extending over several weeks and carried out at successively decreasing temperatures.

The invar from a single melt will not, in general, be of absolutely uniform properties throughout, the expansion variations not being more than $+ 0.03.10^{-6}$, so that, in determining lengths to one part in ten million, it appears safe to use the same expansion formula for all the pieces from a given melt.

The mechanical properties are about as follows: Tensile strength, 35 to 60 kg. per sq. mm., or 50,000 to 85,000 lb. per sq. in.; elastic limit, 5 to 21 kg. per sq. mm., or 7,000 to 30,000 lb. per sq. in.; elongation, 40 to 50 per cent; reduction of area, 40 to 65 per cent; scleroscope hardness, 19; and Brinell hardness, 160. (*Circular of the Bureau of Standards*, vol. 4, no. 58, 1916, 68 pp., 38 figs., and a selected bibliography of books and articles on nickel steel. *g.*)

Copper-Clad Steel Wire

Some data on the manufacture and properties of the so-called "Copperweld" wire.

This wire is manufactured by taking a steel bar about 4 in. in diameter by about 30 in. long, pickling, cleaning, and covering it with a specially prepared flux. This bar is then placed in a mold 5⅛ in. in diameter by about 30 in. long. The bar and mold are placed in a furnace and allowed to remain there until the desired temperature is obtained, when copper heated to a temperature of 1980 deg. is poured over the steel bar, filling the space between the bar and the mold. The bar thus obtained is reheated, hot-rolled, and drawn into wire.

The wire is said to have an absolute weld between the copper and the steel without voids, so that torsions, twists or hammering will not separate the copper from the steel core. Neither is the weld affected by a change of temperature from extreme heat to a sudden plunge in cold water. According to the claim of the maker, the wire has a tensile strength about 60 per cent greater than hard-drawn copper wire of the same size, and will stand approximately 126 per cent more strain than copper wire before reaching the elastic limit. It weighs approximately from 7 to 10 per cent less than copper wire of the same diameter and length. (*Electric Railway Journal*, vol. 48, no. 10, p. 409, September 2, 1916, 2 pp. *d.*)

RUBBER VULCANIZATION ACCELERATORS. Andrew H. King

The degree of vulcanization can be greatly influenced by a change in either time or temperature. Thus a stock which cures ordinarily in 40 min. at 40 lb. steam pressure can be vulcanized in 25 min. at 60 lb. However, the increase in working steam pressure is expensive and sometimes unsatisfactory. It is far better to add from 1 to 2 per cent of some good accelerator and properly cure the rubber at low pressure than to run chances of injuring the nerve at high temperature.

The author discusses several accelerators, mineral and organic. A peculiar fact is brought out. By a combination of accelerators the resulting increase in speed is greater than the sum of the individual increases when acting alone. For example, the effect of 1 per cent tetramethylenediamine and 1 per cent piperidine exceeds the sum of the effects of the same catalyzers when mixed in separate batches. (In connection with this article attention is called to the following two abstracts: JOURNAL, December, 1915, p. 725, and September, 1916, p. 751.) (*Metallurgical and Chemical Engineering*, vol. 15, no. 5, p. 231, September 1, 1916, 4 pp. *p.*)

THE FREEZING POINT OF MERCURY. R. M. Wilhelm

The temperature at which mercury freezes is of importance to thermometry. It marks the lower limit to which mercurial thermometers may be used, and its location at about—39 deg. cent. makes it of value as a fixed point of the temperature scale below 0 deg. cent. A paper by the Bureau of Standards, and which is now in press, gives the result and describes in detail the method used in making a redetermination of this constant. The temperature measurements were made by means of platinum resistance thermometers whose constants had been previously determined by calibration at 0 deg., 100 deg., and 444.6 deg. (the boiling point of sulphur). All the evidence at present available indicates that the platinum resistance thermometer so calibrated defines temperatures in agreement with those given by the standard gas thermometer down to 40 deg. The value obtained at the Bureau,—38.87 deg., is in very good agreement with that found by Henning in 1913 at the Reichsanstalt, Germany, who also used platinum resistance thermometers and obtained—38.89 deg. (*Bureau of Standards*, Scientific Paper, no. 294, advance abstract.)

THE ANNEALING PROPERTIES OF COPPER AT TEMPERATURES BELOW 500 DEG. CENT., WITH PARTICULAR REFERENCE TO THE EFFECT OF OXYGEN AND OF SILVER

G. V. Caesar and G. C. Gerner

Brief historical sketch of the research on the relations between the physical properties of copper and annealing conditions on one hand and chemical composition on the other, followed by a report of an experimental investigation carried out by the authors.

This experimental investigation was conducted along the following lines:

(*a*) A study of half-hour annealing effects (as measured by the scleroscope) produced by the addition of known small amounts of oxygen and silver alone and combined to specially prepared pure copper free from all but the smallest traces of oxygen, and of similar effects observed in the case of commercial electrolytic (multiple) copper. All samples were reduced 66⅔ per cent in area of section before annealing.

(*b*) A determination of the position of the zone of rapid softening (*zone de détente*) in the commercial samples (electrolytic copper) after annealing for such periods of time as appeared to produce an equilibrium effect at each respective temperature. In this work both hardness and tensile tests were made and three sets of results corresponding to three separate values of reduction by cold rolling were obtained.

The method of investigation adopted was essentially that used by Rose in studying the effects of impurities on the annealing properties of gold (*Journal, Institute of Metals*, 1913). Among other things these tests confirmed the fact that slight changes in temperature brought about by annealing and consequent recrystallization are very sharply indicated by scleroscopic tests, and the writers indicate certain precautions necessary to insure a good performance from this instrument.

The data of the tests are presented in the form of tables and curves. In general, the writers come to the conclusion that it seems reasonable to believe that an impurity which is completely dissolved in the solid metal and thus constitutes an integral part of each strain-hardened grain will be more effective than an undissolved impurity in promoting or retarding the structural changes brought about by annealing. The influence exercised by cuprous oxide on the softening characteristics of copper is ascribed to its property of preventing gas absorption by the copper. As regards the softening properties exhibited by the different grades of copper tested it was found that in the case of pure copper softening begins at some temperature close to 200 deg. cent., and that the effect is most rapid between 225 and 275 deg. cent., the softening being complete at some temperature between 300 and 350 deg. cent. In samples containing oxide it was found that a marked softening effect is associated with the presence of mechanically entangled cuprous oxide. Recrystallization apparently occurs at a lower temperature than in the case of the material termed pure copper, but an increase in oxygen content from about 0.03 to 0.09 per cent does not materially affect the softening characteristics.

The effect of 0.10 per cent of silver in solid solution in the absence of oxide is pronounced. The original strain-hardened condition persists up to some 300 deg. cent., and the most rapid softening effects take place in the neighborhood of 350 deg. cent. In order to test the effect of a definitely known but small amount of silver together with a rather large amount of oxygen, an alloy was prepared containing 0.002 per cent of silver and 0.08 per cent of oxygen. Its softening properties approximate very closely those of pure copper, and the oxygen and silver appear to have effectively neutralized one another in this respect. Since silver is a common impurity in electrolytic copper and since even in small quantities its effect on the annealing properties is so profound, it is probable that variations in silver content are largely responsible for the wide lack of agreement among the annealing curves obtained by different investigators, and to interpret the curves obtained it is almost indispensable to have information with respect to the nature and extent of the contaminations of the copper, as well as the degree of reduction and time of anneal.

The paper discusses also the position of the zone or rapid softening in one grade of electrolytic copper ("D R W") after periods of annealing intended to develop equilibrium effects; scleroscope control tests; method of annealing the tensile test strips; hardness tests on the rolled and annealed tensile test strips and tensile tests on the rolled and annealed test strips. In connection with the hardness tests there was observed in certain cases a marked difference in the hardness values obtained from duplicate strips which were treated side

by side under the same conditions, the variations in the hardness values obtained from different strips annealed under strictly comparable conditions being as high as two- to four-point. These annealing variations are ascribed to segregation of silver in the original cake from which these strips were obtained. Among other things the writers come to the following two conclusions:

1. That strain-hardened copper softens and recrystallizes as would be required by the theory (Tammann) that the permanency of the strain-hardened condition depends upon the number or concentration of inner surfaces developed by deformation in any region and the temperature (and time) of anneal, and in accordance with a recent interpretation (Mathewson) of the conditions encountered in material rolled to a succession of gages.

2. That after what appears to be a complete anneal there still remains some effect due to the manner of working before the anneal, as shown by the higher tensile strength found in those specimens which had received the most severe reduction. (Paper presented at the Annual Meeting of the American Institute of Metals, September 11-15, 1916, at Cleveland, Ohio).

COLD-ROLLING STRIP STEEL, Edward K. Hammond

Cold-rolled steel is produced by rolling the metal cold, which gives two advantages: first, the tendency to oxidize and form a scale (which cannot be avoided when steel is rolled hot) is entirely overcome by cold-rolling, so that the steel may be given what is known as a bright finish; second, the elimination of oxidation enables the gage of the steel to be held within very close limits, such as on the thicker gages within 0.0015 in., while the thinnest gages are guaranteed to be within 0.00025 in. of the specified thickness. Further, the process of cold-rolling enables the steel to be rolled true to gage as thin as 0.003 in., which would not be practicable with hot metal because of uneven heating and expansion.

The article describes the selection of the raw materials, the annealing gas medium furnaces, the pot annealing furnace and muffle annealing furnace, as well as the machinery used for the operations of rolling.

After the steel has been annealed it goes to the pickling department where it is subjected to a treatment which removes all the oxide scale that was produced on the metal during the hot-rolling process. The pickling process consists of immersing the rolls of steel in vats of sulphuric acid, which causes the scale to be removed. The acid consists of a 5 per cent solution of sulphuric acid which has a density of 66 deg. Baumé at 60 deg. fahr. In the case of low-carbon steel the time that the metal is left in the vat is not important, but with high-carbon steel great care must be taken and the steel should not remain in the acid for more than three or four minutes. It is important for the stock to be uniformly covered with scale before pickling, otherwise the pickled stock will have a "pitted" surface and therefore cannot be converted into good cold-rolled steel. After the pickling operation has been completed, the steel must be washed immediately in order to remove the acid. To make assurance doubly sure, the steel is removed from the water and plunged into a vat containing a diluted solution of lime water, which has the further advantage that when the steel is removed from the vats and given time to dry it is coated with a film of lime, which keeps both air and moisture from coming into contact with the metal, and so protects it from rusting. The cold-rolling in the plant described in the article (Schwartz-Herrmann Steel Company, Floral Park, Somerville, N. J.) is done on mills imported from Germany.

In cold-rolling it is highly important to avoid chatter and vibration, as such a condition would be shown by irregularities in the surface of the product. This feature is taken care of by having the power transmitted to the rolls through herring-bone gears and shackle bars, which serve as a double precaution against vibration.

The amount of reduction which can be obtained for each pass through the rolling mills depends upon the analysis of the steel; with low-carbon steel the reduction may be as great as 0.022 in. for each pass, and this will be gradually decreased until the final pass will only reduce the thickness of the metal about 0.005 in. In the case of high-carbon stock the reduction is much less.

The rolls are lubricated with a special grade of oil known as "Roll Oil," which is of about the same consistency as cylinder oil, but very carefully compounded, to be sure that it has neither acid nor alkaline admixtures, as either condition would spoil the bright finish of the cold-rolled steel.

The article describes further the methods of trimming the edges of stock, cutting strips into stock length, hardening and tempering, and, when necessary, polishing. (*Machinery*, vol. 23, no. 1, p. 1, September, 1916, 6 pp., 14 figs. *d.*)

EFFECT OF SUGAR ON CONCRETE

The fact that even a very small amount of sugar in a concrete mix is injurious to good work has long been known. The author cites tests which show that as small an amount of sugar as 1 lb. to ten bags of cement will cause failure.

The knowledge of this fact of the influence of sugar on concrete may save serious loss. For example, it is not advisable to place concrete floors in a candy factory.

It appears, however, on the other hand, that weak solutions of sugar will not affect concrete once it has become thoroughly hardened. In fact, a sugar solution has been recommended as a hardener and dust preventive. (*Concrete*, vol. 9, no. 2, p. 61, August, 1916, 1 p. *c.*)

Firing and Fuel

CHAIN SCREEN DOORS, H. H. Wiegand

Description of chain screen doors, mainly of the Wiegand type.

These chain screen doors consist usually of a multitude of freely hanging individual strands of steel chain suspended close together from a bar in a manner to form a continuous sheet or curtain of chain not unlike the Japanese screen. This curtain of chain hung before the uncovered opening of a furnace effectively hinders the heat, glare, gases and sparks from leaving the furnace and checks the entrance of cold air. The loosely hanging strands of light chain are parted with ease and pressed aside by the tools or other objects projected into the furnace, only to fall together again when entrance has been effected. The interstices in the links of chain permit an unhampered view of the interior; in fact, a better survey may be obtained than under ordinary conditions, as the glare is toned down and the effect is similar to looking into a furnace through a piece of wire gauze.

In a boiler room where the Wiegand chain doors have been employed for about three years, experiments were made to obtain an idea of the effectiveness of the device in avoiding the losses arising from the frequently opened stoking door.

A thermometer was fixed on a standard in the fire room at a point opposite this door and 10 in. therefrom. This position was chosen as being near to the one usually taken by the fireman when stoking or cleaning the fire. When the ordinary fire door was thrown open and the incandescent fire bed exposed, as is the case whenever the furnace is coaled or cleaned, the thermometer rose to 400 deg. fahr. On covering the furnace opening with the auxiliary chain door the thermometer dropped to 135 deg. fahr., and the bare, unprotected hand could be held anywhere in front of the screen opening without discomfort. (*The Journal of Industrial and Engineering Chemistry*, vol. 8, no. 9, September, 1916, p. 836, 2 pp. *d.*)

SOME EXPERIMENTS IN NATURAL-DRAFT OIL BURNING. Lieut. L. R. Ford, U. S. N.

An interesting description of experience in oil burning on the U. S. S. *Fulton*.

At the time the ship was commissioned, the steam necessary to operate the auxiliaries was supplied by a Roberts water-tube boiler equipped with one large burner, which used either steam or air as an atomizing agent. The air for combustion was supplied by natural draft through two small ventilators and through the door between the engine room and fire room. After a disastrous furnace explosion, due to the burner flame being extinguished and the furnace becoming filled with explosive gas, which ignited, the boiler was fitted with two of the Bureau's Standard Type B air registers and Type I burners. These burners atomize the oil mechanically and are designed for use with forced draft. In addition, a second boiler of the Almy water-tube type was installed, which made the room quite crowded and curtailed the already limited air supply.

As soon as the ship was ready to leave the Navy Yard troubles began. When the burners were lighted under one boiler, it became evident that the combustion was very poor. Several schemes were resorted to. Small portable electric blowers were placed on the fire-room floor plates so as to discharge against the registers in the furnace front. This helped only slightly. A sheet-metal box built on the boiler front so as to completely enclose the registers and burners and connected with two ¼-h.p. portable blowers proved to be a failure. A small box was then built that would stand on the floor plates in front of the burners, with the two ¼-h.p. blowers connected so as to discharge into the box. This improved the combustion, but far from sufficiently. So much soot was deposited that it became necessary to establish a routine requiring that the tubes be blown with steam once every hour or 24 times each day.

The oil pressure habitually carried with the Bureau type of burner was 200 lb. It was found that by reducing the oil pressure much better combustion was obtained, but the oil was then insufficient to maintain the steam pressure. Several types of experimental burners with either air or steam atomization were tried, but without much success. Finally, the following system was adopted on the advice of Lieut. A. M. Penn, U. S. N., in charge of the Fuel Oil Testing Plant at the Navy Yard, Philadelphia.

The Bureau Standard Type B registers were removed from the furnace front of the Roberts boiler and a bar of ¾-in. by 3-in. flat iron was supported across the front of each opening in the furnace front on ¾-in. studs, these studs projecting 10 in. from the furnace front and being provided with threads and nuts for adjusting the bar for distance. Each bar was drilled at its center large enough to permit the insertion of a burner.

The burner itself was modified as shown in Fig. 2A. A funnel-shaped diffuser was made of sheet iron and attached to the end of a piece of 1¼-in. pipe 4 in. long by means of a band clamp. This clamp method of securing the diffuser on the pipe was preferable to screws or rivets, as it permitted easy removal of the diffuser. The included angle of the diffuser was selected after several experiments as 90 deg., and the diameter at the large end was made 4⅝ in. The pipe was slipped over the tip in such a manner as to permit adjustment of the distance the burner tip projected into the diffuser.

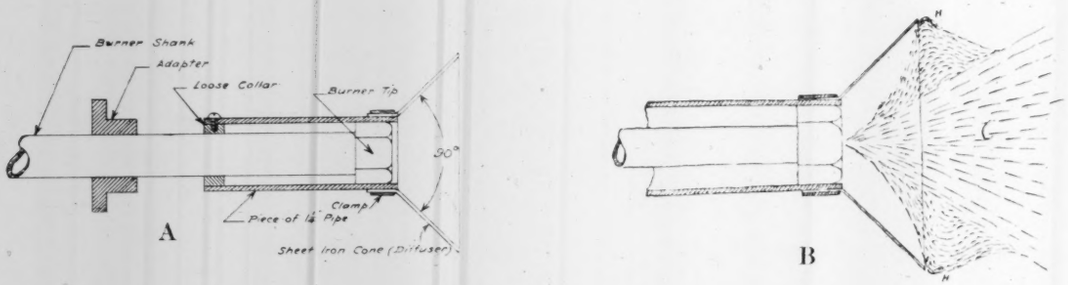

FIG. 2 IMPROVED NATURAL-DRAFT OIL-BURNER

When this burner was lighted a most interesting action was observed. With the diffuser drawn well back toward the rear, the flame would jump away from the burner, but when the diffuser was pushed forward it would pick up the flame, and a short cone of clean flame would result. When the diffuser was adjusted to the best operating position, a halo of white flame would appear around the edge, as shown in Fig. B. The main body of the flame retained its cone shape, as shown at C, this cone of flame extending back to the burner tip; but part of this flame seemed to draw out to the diffuser and curl down from the edge, as shown at H. The combustion obtained with this arrangement was very good, indeed. The article proceeds to describe in detail the rebuilding of the furnace apparatus.

Among the modifications introduced were the installation of vertical fins of thin sheet metal in the shape of a helix around the circumference of the conical openings in the furnace, to promote mixing of air and fuel by giving the entering air a rotary motion. Another improvement was the mounting on the head of the oil line of a large air chamber. This chamber kept the oil pressure steady, the effect of which was quickly noted at the burners. When the diffusers were adjusted to get the halo around the edges, it remained there without further adjustment. What surprised the ship engineers most was the low oil pressure required to maintain the steam

pressure and the wide range of pressure through which the burners could be operated smokelessly. Under the old conditions it had been necessary to operate the burners under an oil pressure of 200 lb. It was now found that the steam necessary to meet the normal demand of the ship could be evaporated with an oil pressure of 50 to 100 lb., and the pressure had to be raised to 200 lb. only when an extra demand for steam was made.

In fact, it was found that the steam pressure could be quickly and closely regulated by varying the oil pressure, which could be done by varying the spring tension of the regulator valve on the oil pump. Steam control was thus reduced to the mere screwing of a nut up and down with a wrench, a novelty which strongly appealed to the firemen.

The helical vanes, in addition to giving the air a rotary motion and thereby promoting mixture of air and oil, serve a useful purpose in intercepting the radiant heat from the flame. It is found that since they were installed the heat in front of the boiler is now greater than when the closed registers were in use. (*Journal of the American Society of Naval Engineers*, vol. 28, no. 3, p. 641, August, 1916, 14 pp., 6 figs. *de.*)

Foundry

Reclaiming Waste Molding Sand

Description of the equipment recently installed by the Modern Foundry Company, Oakley, Cincinnati.

This equipment consists simply of two belt conveyors, one with 23-ft. centers and the other with 26-ft. centers. Jeffrey 18-in. belts are used, the pulleys and motors being mounted on structural-steel frames. The refuse is shoveled into the shorter conveyor and passes over a Cutler-Hammer magnetic pulley having the magnetic coils on the inside of the pulley. The metal as it passes over the pulley adheres to the belt, while the sand is discharged upon the second conveyor from which it is dumped into the car. The metal is carried partly around the magnetic pulley, and is dumped into a chute at the point where the belt leaves the pulley. These conveyors have a capacity of one ton a minute and are each electrically driven with a 1-h.p. motor.

The company states that the amount of material reclaimed in six weeks has more than paid for the original cost of the equipment. (*The Iron Age*, vol. 98, no. 10, p. 505, Sept. 7, 1916, 1 p., 2 figs. *d.*)

A Centrifugal Machine for Casting Pipe

Description of a new method of casting pipe by using centrifugal force, invented by two Brazilians, D. Sensaud de Lavaud and Fernando Arens, Jr.

The inventors have made numerous unsuccessful attempts to produce cast pipe in a permanent rotary mold. The metal did not spread evenly over the surface of the mold, the pipe was brittle, and there was great trouble in extracting the pipe. Finally, however, they claim to have succeeded in producing good pipe by working along the following lines: (1) A permanent, rotary, and *cold* mold (the condition of the mold being cold appears to be of the highest importance); (2) immediate extraction of the pipe after solidification; (3) the use of very hot iron; (4) a silicon content of 1.80 to 2.50 per cent.

It is stated that at present thirteen of the new machines are operated commercially in two plants in Brazil, turning out various sizes of pipe from 4 in. to 15 in. in diameter and from 4 ft. to 14 ft. long, and that a machine has been built in the Buffalo district which has produced for exhibition and other purposes a quantity of 4-ft. 4-in. pipe.

The operation of the machine is briefly as follows: Regulated quantities of cast iron are introduced into a rapidly revolving water-cooled cylinder, where, by the centrifugal force exerted, the metal is spread uniformly upon the surface of the mold, and within a few seconds the pipe is withdrawn from the other end of the machine at a white heat. The pipe is not subjected to any further treatment except tarring.

According to the theory of the inventors, the metal coming in contact with the cold mold will congeal at once, forming a solidified crust which creates a centripetal force; the pipe then detaches itself from the surface of the mold and the space between the mold and the pipe becomes an insulating chamber, in which the air, which is at a high temperature, graduates the solidifying of the molten mass, and at the same time anneals the crust first formed.

It is claimed that when casting by the new process the metal solidifies probably in two or three seconds. This means that the segregation or separation of impurities is impossible, so that a completely homogeneous mass is formed, in which all the parts are equally distributed and the metal is of a fine, close grain. It is also claimed that the action of the centrifugal force of the metal compresses and expels the air, preventing gas holes and forming a more solid and denser metal.

Tests have been made on various sizes of this new pipe by the Department of Water of Rio de Janeiro and the Department of Water and Sewerage Works of Sao Paulo, Brazil, in which it was found that the pipe could stand very high pressures. The figures are not reported, as there appears to be some uncertainty about them. It is also claimed that the new pipe is less subject to corrosion than ordinary cast pipe. (*The Iron Age*, vol. 98, no. 10, p. 506, Sept. 7, 1916, 4 pp., 8 figs. *d.*)

Waste Foundry Sand, H. B. Swan and H. M. Lane

The first part of the paper is written by H. B. Swan, who sent to a number of large American foundries a set of ten questions covering the use of foundry sand and the recovery of old sand. It was found that with one or two exceptions the burned sand was either loaded in freight cars or hauled away in wagons to some dumping ground, the cost of disposal varying from 30 cents to $1.50 per ton. Two or three replies from larger foundries stated a cost of $24.00 per day to dispose of their burned sand. One foundry disposes of some of its waste sand as a filler for a fertilizer, another uses some of its refuse sand for concrete mixture. Burned sand has been found good for putting in foundations for machinery. When it was used in making concrete walls for a building, the flour in the cores made the walls flake; this flaking continued for a period of at least one or two years after the structure was completed, and was especially noticeable after a continued wet spell.

The second part of the paper is written by H. M. Lane, a consulting engineer of Detroit, who was employed about two years ago by a number of Detroit manufacturers to experiment in washing and cleaning the refuse sand from their shops.

Two important considerations are treated in this paper, as follows: A process which is successful with steel foundry sand might fail utterly with brass foundry or aluminum foundry sand, owing to radical differences in characteristics of the different materials. The percentage of fire clay used in steel foundry mix is relatively small, and the so-called wearing-out of the sand is due mainly to the stopping of the fine passages

by small grains, resulting in the breaking up of the larger grains under heat and from dry or burned bond material.

Another fact is that the mass law of chemistry influences very largely the temperature at which a given size of grain will start to melt or burn into the casting. Very fine sand will burn into a steel casting several degrees lower than coarse sand, which makes it necessary to free the sand from these small and particularly angular grains. For such work a cleaning process that will remove the burned clay and the fine sand dust is necessary.

The process which will produce at lowest cost a product just good enough to use is the one that will ultimately be used, even if other systems may give a better though more expensive product. In steel foundry practice the ultimate factor is the cost of a ton of finished castings; and a process which recovers, say, 80 per cent of the sand in a fairly usable condition may be better than one which recovers 90 per cent in a better condition, but at a higher cost.

For the thorough cleaning of certain classes of sand, the wet process seems to be the best, but it necessitates first a scrubbing and then a washing, and takes quite a complicated plant, though the actual cost of cleaning per ton is low.

The author believes that it is advantageous to clean the coarse sand, but not the exceedingly fine brass or aluminum molding sand. In some cases, passing the sand over a series of sieves, which will first take out the coarse waste material and will next remove the fine or dust material, has been found to give a good product for rebonding for use in foundry work for a considerable line of gray iron castings. (Paper presented at the Annual Meeting of the American Foundrymen's Association, September 11-15, 1916, at Cleveland, O.)

ALUMINUM CASTINGS AND FORGINGS, P. E. McKinney

Discussion mainly of the influence of manganese on aluminum and the use of manganese-aluminum alloys for castings.

The most dangerous impurities encountered in aluminum alloys are carbon, silicon and iron; hence only carbonless manganese produced alumino-thermically has been used by the writer.

In producing an alloy for casting purposes, an empty crucible is set in the furnace and heated to a bright red. The requisite amount of hardening alloy is added and melted as quickly as possible. In cases where there is danger of introducing sand into the crucible, powdered flux, made by melting 60 per cent of potassium chloride and 40 per cent of cryolite and powdering the mixture, is used. This flux tends to dissolve the silicon and keeps it from combining with the aluminum.

The alloys of aluminum containing manganese have a slightly greater shrinkage than those containing copper alone, and due allowance must be made by using ample risers and chill plates on intricate castings.

The writer has made a number of tests on the physical properties of manganese-copper alloys.

The following are typical physical properties obtained on bars of this alloy forged to one inch square and turned to standard size tensile specimens.

No special melting furnaces or devices for handling the metal were found to be necessary for the production of alloys of aluminum containing manganese which can be melted in natural draft pit furnaces with only the ordinary precautions. A rich hardener of definite proportions and comparatively low melting point can be best made by alloying the hardening elements with a small amount of aluminum.

Soft alloy containing:

Manganese 1.00 per cent, copper 2.00 per cent, aluminum, 96.50 per cent.

	Tensile Strength	Yield Point	Elongation	Reduction
Cold finished	27750	27750	12.00	47.00
Hot finished	21083	12223	26.7	48.7
Intermediate	25617	22918	17.4	52.00

Hard alloy containing:

Manganese 2.00 per cent, copper 3.00 per cent, aluminum 94.50 per cent.

	Tensile Strength	Yield Point	Elongation	Reduction
Cold finished	31930	30000	9.75	35.3
Cold finished	34123	33000	4.00	11.25
Cold finished	30405	30000	11.25	30.78
Hot finished	27450	15000	21.95	56.0
Intermediate	28670	22000	21.00	50.4

Sections cut from thin drop forgings which were cold finished have shown tensile strength as high as 40,000 lb. per sq. in. (Paper presented at the Annual Meeting of the American Institute of Metals, September 11-15, 1916, at Cleveland, O.)

Hydraulics

EXPERIENCE WITH WOOD PIPES IN NEW HAMPSHIRE, Arthur W. Dudley

Wood pipe has been in use for centuries, and when properly laid and made from proper material is remarkable for its long life. The writer states that he has in his office a section dug up in Bowdoin Square in Boston during the excavation for the subway that is as sound as when cut from the forest, although it is a part of Boston's first water system laid more than two hundred years ago.

Wood pipe was displaced by cast-iron because the old method of making it limited its inside diameter to the size of the log, 6 in. inside diameter being nearly the limit of such pipe. Modern methods of making wood pipe permit of producing practically unlimited diameters.

As to methods used in pipe making, the writer, after experiments, came to the conclusion that the sleeve method of connection may be strong, but the difficulty in coating the exposed ends of these sleeves, and the fact that they would not be saturated at all times, exposes them to danger from decay. He prefers tenon-and-chamber, flat-hooped pine pipe to pipe made of Douglas fir, because of the greater brittleness of the latter. The author describes several of his own experiences in laying wood pipe. In one case, at Pembroke, N. H., wood pipe was chosen mainly for the reason that the Manchester & Concord Electric Railway passes over almost the entire length of Pembroke Street, and, as no provision for a return current is made there, an iron pipe line would undoubtedly have formed this circuit, with imminent danger of electrolysis, while a wood pipe, being a non-conductor, was safe. To sum up the situation, wood pipe has besides the saving in cost of both pipe and installation these advantages:

1 It is preserved by water, and not rusted or corroded by it.
2 It is not corroded by any substance, or destroyed by acids or salts.
3 Its carrying capacity is 20 per cent greater than that of cast-iron pipe, and remains constant, while that of metal pipe decreases with age.

4 It does not taint or affect fluids going through it.
5 It does not burst if frozen, the elasticity of the wood preventing it.
6 It requires less labor and experience to lay in place than metal pipe, and a considerable saving can be made here.
7 It can, when service pipes are not taken off, be laid in shallower ditches than metal pipe, for it is not so easily affected by frost.
8 In the writer's experience, while more or less joints show slight leakage when the pipe is first filled, they soon swell up and give less trouble in the end than cast-iron pipe. (*Journal of the New England Water Works Association*, vol. 30, no. 3, p. 318, September, 1916, 8 pp., 2 figs. *dpc.*)

Internal Combustion Engineering

The Maclaren Marine Paraffin Engine

Description of an engine manufactured in Dumbarton, Scotland, in sizes from 8 to 28 h.p.

Of particular interest is the vaporizer and carburetor, which embodies the application to low-power engines of blowlamp heating for starting on kerosene. The arrangement consists of a simple casting, to the outside of which the blowlamp is applied for a few minutes before starting up. There is also a special arrangement whereby the engine can be started on gasoline and be changed over to run on kerosene by a movement of the throttle lever. In this arrangement the gasoline vapor does not go through the kerosene vaporizer, consequently a suitable combustible mixture is supplied at once to the cylinders whether the engine is hot or cold. This eliminates the difficulty often experienced at starting with the ordinary type of vaporizer when it is too cold for starting on kerosene and too hot for gasoline. (*Engineering*, vol. 102, no. 2642, p. 152, August 18, 1916, 2 pp., 6 figs. *d.*)

Silencing the Exhaust and Utilizing the Waste Heat of Internal-Combustion Engines

F. W. Rixon, Bristol, England, has recently patented in Great Britain a silencer for internal-combustion engines, in which thermopiles are employed for the recovery of the energy which would otherwise be dissipated as waste heat.

The cylindrical wall of the silencer is composed of a number of substantially triangular thermo-couples lying in transverse planes and spaced angularly by an insulating material. Each couple comprises a pair of triangular plates of different metals properly alternating, the apices of the plates being bent forward and united to one another by welding. The plates in each series are separated from one another by thin sheets of insulating material. It is expected that the gases when passing will heat the plates and at the same time lose most of their energy by friction. No data are given as to any tests. (*The Mechanical Engineer*, vol. 38, no. 969, p. 115, August 18, 1916, 1 p., 2 figs. *d.*)

Large Gas Engine Utilizing Water-Jacket Heat, F. L. Prentiss

The gas-engine plant installed in the new foundry of the Turner & Moore Mfg. Co., Detroit, is of interest because it has been designed to use comparatively expensive gas (55 cents per 1000 cu. ft.), and because the heat from the water jacket is utilized for producing by-product steam for heating a soda kettle and also for providing the hot-water supply.

The water-jacket cooling is designed according to the Meriam system previously described in The Journal (May, 1915, p. 295). This system is based on a discovery that with the water flowing through the jacket at a high rate of speed (about ten times higher than the usual) very good cooling of the cylinder can be obtained with the water even above the atmospheric boiling point. This is due to the fact that the high speed of the flow prevents the formation of steam and air bubbles and their adhesion to the cylinder walls, it having been found that it is these bubbles that, with the usual speeds of water, form at a certain temperature an insulating layer over the cylinder walls and interfere with their further cooling.

In the present instance the water passes from the water jacket into an enclosed tank which is connected with the suction side of the centrifugal pump, and a constant circulation is maintained between the cylinder jackets and the tank. A pressure of 4 to 5 lb. is maintained on the tank, while the pressure on the cylinder jackets is about 25 lb., this higher pressure being due to the resistance caused by forcing a large volume of water through the jackets rapidly. (*The Iron Age*, vol. 98, no. 8, p. 389, Aug. 24, 1916, 3 pp., 2 figs. *d.*)

Two-Crank, Four-Cylinder Combustion Engine, C. W. Shafer

A radically different design of internal-combustion engine, manufactured by the Field Motor Company, at Grand Rapids, Mich., is of the horizontal type, double opposed, and has but two cranks and two connecting rods for four pistons.

The engines are joined in pairs by rods, which practically gives a continuous piston. The tie rods have sliding fits on each side of the cranks and also on the top and bottom of each crankshaft bearing, so that the rods have no room for play and the amount of vibration is reduced to a minimum.

The carburetor (any standard type) is located above the cylinders, and one manifold only is used for 4- or 8-cylinder engines. Gasoline is used for starting the engine and kerosene or distillates for running it.

The arrangement of the manifold permits firing of the charges clockwise, 1, 2, 3, 4, a perfect balance being thus secured. With an 8-cylinder motor two explosions occur for every revolution of the crankshaft.

The article gives a sectional view of the engine and a view of the exterior of the motor. (*The Practical Engineer*, vol. 20, no. 16, p. 706, August 15, 1916, 2 pp., 3 figs. *d.*)

Power Plant of the Burro Mountain Copper Company, Charles Legrand

This power plant is of interest, first, because it uses the largest stationary Diesel engines in the United States, and second, because it is located at 5950 ft. elevation, which latter fact introduces certain complications in the operation of the engines. The plant has two five-cylinder vertical Diesel engines, which are rated at 1250 b.h.p. at sea level, and have cylinders of 20.6 in. diameter and 26 in. stroke. Each engine has a scavenging cylinder of 41.25 in. diameter and 23.6 in. stroke, also a three-stage four-cylinder high-pressure vertical compressor, both directly connected to the engine.

This compressor delivers the air necessary for fuel injection and for starting the engine. The scavenging pump, which is larger than usual, delivers the air to expel the products of combustion and fill the cylinders with fresh air at the beginning of the stroke. This pump was increased in size to be able to fill the cylinders with air at 2½ lb. gage pressure at

the beginning of the stroke, which gives nearly the same initial absolute pressure and allows the engine to generate nearly the same indicated horsepower as it would at sea level. The work done in the scavenging pump is, however, increased, and the horsepower available is approximately 95 per cent of the sea-level output.

The fuel consumption per horsepower is increased over sea-level conditions because of the extra work of the scavenging pump and the resulting lower mechanical efficiency of the engine when operating at the elevation of this plant.

The fuel used is California asphaltum base oil of 14-18 deg. Baumé gravity and about 18,360 B.t.u. The paper gives detailed costs of power per month and per kw-hr. available, the data of cost per month being given also in detail for labor, fuel oil, lubricating oil, miscellaneous supplies, and repairs. The repair cost is high, for soon after operations were started the construction account was closed, and several items, such as labor for installing recording thermometers, etc., were charged to repairs.

The greatest trouble was with the helical gears driving the cam shafts. These gears have a tendency to get loose, and one of them split from the keyway. The exact cause of this trouble has not been ascertained, but it has been much reduced since iron bands were shrunk on the hubs of the gears The lubricating-oil expense is given in detail. It does not seem to be excessive, and it is expected that it will be further reduced by the use of separate pumps to each point where the oil is delivered in the cylinders, insuring a definite quantity of oil. The present engines have one pump delivering to four points, and it happened once that one of the oil pipes became plugged and gave slight trouble on one piston. The maintenance cost is still in doubt.

The operation of the engines in parallel is very satisfactory, even when the load is slight, and on the whole the writer is satisfied with the operation of the plant and its cost as compared with what would be the case with a steam plant of the same capacity running under the same conditions. (*Bulletin of the American Institute of Mining Engineers,* no. 117, p. 1531, September, 1916, 8 pp., 4 figs. *dA.*)

Machine Design

ADOPTION OF THE INTERNATIONAL STANDARD OF SCREW THREADS BY THE FRENCH ARTILLERY

By a recent order dated March 22, 1916, the French artillery instructs all its contractors to use the International Standard (S. I.) for all screw-thread work done for that department.

The article gives a complete specification of the International Standard screw threads, together with instructions as to the use of the various gages, and in particular instructions for their use for all work done for the French artillery department. (*Bulletin de la Société d'Encouragement pour l'Industrie Nationale,* vol. 126, no. 4, p. 74, July-August, 1916, 30 pp., illustr. *d.*)

SOME STANDARD MAKES OF FRICTION CLUTCHES

A description of a number of types of friction clutches of American manufacture, taken from the literature of the several manufacturers. No attempt was made by the publishers to verify the claims made, but the collection is of considerable interest, as it affords a general view of the state of the art of manufacturing friction clutches. The following clutches are described and illustrated:

Moore & White high-speed clutch (metal-to-metal, multiple-disk type. Interesting system of lubrication)

Reeves wood split-pulley clutch

Caldwell double-disk friction clutch

Universal Giant friction clutch (outer ring covers friction surfaces which are wood and iron)

Medart friction clutch pulleys (hubs and sleeves interchangeable)

Bicknell Thomas clutch (two friction shoes work on the inner surface of the hub, which latter is lubricated from special oil chambers)

Falls friction clutch (ring-type clutch pulley, sleeves made in halves)

Thomas Patent Empire friction clutch.

Edgemont countershaft clutch (solid cast-iron pulley, with ring cast on the spokes to receive the friction)

Ideal Multi-Cone clutch (multiple-disk cone type, the cones running constantly in oil)

Hilliard single-disk clutch (movable friction surface is drawn towards the stationary friction surface by a specially designed worm thread so that the friction plate comes in contact with the friction material smoothly and gradually)

Erie Standard friction clutch pulley (hard wood; the clutch pulley has a long, spiral, self-oiling hub made in halves)

Meeseco short shaft clutch (cone type, all-metal, with the friction wearing surface of hard babbitt)

Hanson friction clutch (dust-proof friction surfaces are either steel and iron bathed in oil, or steel and compressed friction paper)

OK combined friction and positive clutch (in engaging or starting the load the friction will gradually start the load, and when a certain point is reached the friction will slowly release, giving the steel points a chance to enter a series of holes in the driven part)

S. & S. friction clutch (friction furnished by two sets of wood blocks; clutch is self-centering)

Cleveland friction clutch (expanding-ring, self-oiled, friction surfaces metal-to-metal running in oil)

Conway solid compression clutch (friction-band type)

Johnson friction clutch

Brown friction clutch

Webster steel-plate friction clutch (clutch elements consist of a circular steel plate with rings of a special friction board attached to both faces and toggle-actuated iron mating rings which engage the friction disk for creating the driving connections)

S.-A. steel-plate clutch pulley (friction surface consists of a heavy steel plate or disk both sides of which are shod the entire circumference with hard paper friction board secured to the plate with maple dowels, thus giving a friction surface of both hard paper and hard wood.

Lemley friction clutch (friction contact wood to iron; adjustment made by means of a threaded ring secured to the clutch sleeve; this one ring adjusts all toggles at the same time assuring a like pressure on each toggle)

Hill friction clutch, Smith type (friction surfaces wood against iron. All working parts, including the inside jaws, may be removed parallel to the shaft from the mechanism side without disturbing the main spider casting or pulley; clutch is self-centering)

Frisbie friction-clutch pulley

Tester friction clutch

Dodge patented split friction clutch (friction through an outside disk into which are driven hard-maple blocks presenting end grain)

(*Mill Supplies,* vol. 6, no. 9, p. 41, September, 1916, 16 pp., 30 figs. *d.*)

LAYING OUT SKEW BEVEL GEARS, Reginald Trautschold

The author claims that the skew bevel gear has been generally avoided by both designers and machinists; by the former on account of the difficulty experienced in laying it out, and by the latter because of a fancied intricacy in the method of cutting.

As a matter of fact they are not as difficult to cut as was assumed, although the cost of their manufacture is slightly greater than that of an ordinary bevel gear.

There are two general types of skew bevel gears which, for the sake of brevity, may be referred to as types A and B. In the former a pinion of the ordinary bevel-gear type is employed, the oblique teeth being confined to the gear, and in the latter the teeth are oblique in both pinion and gear. In each type the pitch surface of the pinion is the frustum of a figure generated by the revolution of a straight line about the axis of the figure, the generating line lying in a plane parallel to a plane through the axis, and being neither parallel nor at right angles to the axis, *i.e.*, the figure is a hyperboloid of revolution.

The author gives a general discussion of both types of gears, instructions as to their cutting, and formulae for both types. Only the latter are here reproduced.

NOTATION FOR SKEW BEVEL GEARS

p = diametral pitch;
n = number of teeth in pinion;
N = number of teeth in gear;
X = offset of pinion shaft;
ϕ = angle of offset;
d = pitch diameter of pinion;
D_e = equivalent pitch diameter of gear;
D = pitch diameter of gear;
d' = outside diameter of pinion;
D' = outside diameter of gear;
p' = circular pitch of pinion;
P' = circular pitch of gear;
E' = center angle of pinion;
F' = face angle of pinion;
C' = cutting angle of pinion;
E = center angle of gear (shop angle);
F = face angle of gear (shop angle);
C = cutting angle of gear (shop angle);
E'' = center angle of gear (design angle);
F'' = face angle of gear (design angle);
C'' = cutting angle of gear (design angle);
J = angle increment of pinion;
K = angle decrement of pinion;
d'' = diameter increment of pinion;
D'' = diameter increment of gear;
s = addendum;
V = radius of circle of apexes for pinion;
W = radius of circle of apexes for gear;
X = total offset of pinion shaft = $V + W$;
y = angle of offset for pinion;
z = angle of offset for gear;
R = speed ratio = N/n;
J'' = angle increment;
K'' = angle decrement;
P'' = circular pitch;
d_e = equivalent pitch diameter of pinion.

FORMULAE FOR SKEW BEVEL GEARS—TYPE A

$$d = n/p \quad [1]$$
$$D_e = N/p \quad [2]$$
$$\tan \phi = 2X/D_e \quad [3]$$
$$D = 2X/\sin \phi \quad [4]$$
$$P' = 3.1416D/N \quad [5]$$
$$\tan E' = d/D_e \quad [6]$$
$$\tan J = 2 \sin E'/n \quad [7]$$
$$\tan K = 2.314 \sin E'/n \quad [8]$$
$$F' = E' + J \quad [9]$$
$$C' = E' - K \quad [10]$$
$$s = d/n = D/N \quad [11]$$
$$d'' = s \cos E' \quad [12]$$
$$d' = d + 2d'' \quad [13]$$
$$E = 90 - E' \text{ (shop angle)} \quad [14]$$
$$\tan E'' = D - 2X/d \text{ (design angle)} \quad [14a]$$
$$D'' = s \cos E \quad [15]$$
$$D' = D + 2D'' \quad [16]$$

or, for greater accuracy:

$$D' = D + 2d''D_e/D$$
$$C = E - K \text{ (shop angle)} \quad [17]$$
$$C'' = E'' - KD_e/D \text{ (design angle)} \quad [17a]$$
$$F = E + J \text{ (shop angle)} \quad [18]$$
$$F'' = E'' + JD_e/D \text{ (design angle)} \quad [18a]$$

FORMULAE FOR SKEW BEVEL GEARS—TYPE B

$$V = X/R + 1 \quad [1]$$
$$W = RV \quad [2]$$
$$D_e = N/p \quad [3]$$
$$\tan y = 2V/D_e \quad [4]$$
$$D = 2V/\sin y \quad [5]$$
$$d = Dn/N \quad [6]$$
$$p'' = 3.1416d/n = 3.1416D/N \quad [7]$$
$$\tan E'' = d/D \quad [8]$$
$$E = 90 - E' \quad [9]$$
$$\tan J'' = 2 \sin E'/n \quad [10]$$
$$\tan K'' = 2.314 \sin E'/n \quad [11]$$
$$F' = E' + J'' \quad [12]$$
$$C' = E' - K'' \quad [13]$$
$$F = E + J'' \quad [14]$$
$$C = E - K'' \quad [15]$$
$$s = d/n = D/N \quad [16]$$
$$d'' = s \cos E' \quad [17]$$
$$D'' = s \cos E \quad [18]$$
$$d_e = n/p \quad [19]$$
$$d' = d + 2d'' \quad [20]$$

or, for greater accuracy:

$$d' = d + 2d''d_e/d$$
$$D' = D + 2D'' \quad [21]$$

or, for greater accuracy:

$$D' = D + 2D''D_e/D$$

(*Machinery*, vol. 23, no. 1, p. 32, September, 1916, 5 pp. 2 figs., *pg.*)

Measuring Instruments

VENTURI METERS ON LIVELY LINES, Allen Hazen

Discussion of the accuracy of venturi meters when used for measuring non-uniform flow. The author believes that where variations in flow are rapid so that there are substantial changes in rate in a single second, an error may be introduced. This error may be of considerable importance on lines carrying water directly discharged from reciprocating pumps or from a reservoir into a system where wide and sudden fluctuations in rate of draft are taking place.

The theoretical reason for the error is that the venturi recorders in reality sum up the squares of the flows. The height of the mercury column that is the starting point in the registration is proportional to the square of the velocity. The author takes an extreme case: for half a second the velocity is nothing and for half a second it is 2 ft. per second. For the whole second the average velocity will be 1 ft. per second, but the height of the mercury column will tend to be for the first phase zero, and for the result corresponding to the average height of the mercury column, which is 2, the quantity indicated will be the square root of 2 or 1.41 in place of the true quantity, which is 1. In this case the error of over-registration will be 41 per cent. This is, of course, entirely excessive, but in actual practice errors from 2 to as high as 10 per cent may be anticipated, always in the same direction, namely, registration will be above the truth.

From the writer's experience, the percentage error with

lively lines is much greater at low flows. Errors like those in the venturi measurements resulting from rapid fluctuation in velocity also occur with all other methods of measuring water (pitometer, standard orifice, etc.), which depend upon the effect of velocities upon pressures. What is necessary is some better apparatus for integrating flows of venturi meters. (*Engineering News*, vol. 76, no. 7, p. 293, Aug. 17, 1916, 1 p. *gp.*)

RECENT DEVELOPMENT IN HEAVY TRACK SCALE CONSTRUCTION, J. H. A. Bousfield

Reprint of paper delivered before the 1916 convention of the National Scalemen's Association at Cincinnati, Ohio.

Description of what is claimed to be the largest track scale in the world. It has been installed by the New York Central Railroad Company at West Albany, N. Y., is 100 ft. in length, and is built in six sections, each section designed for a concentrated load of 270,000 lb. The secondary or extension levers are designed to be of sufficient strength to transmit this load applied at each section simultaneously to the fifth lever and thence to the weighing beam, so that the lever system is capable of sustaining a load of six times 275,000 lb. or 1,650,000 lb.

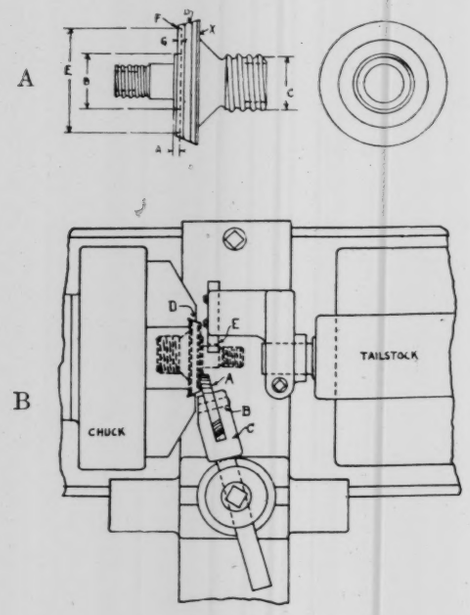

FIG. 3 METHODS OF RECLAIMING RUSSIAN 3-IN. SHRAPNEL FUSE BODIES: A, OUTLINE DRAWING OF FUSE BODY; B, METHOD OF LENGTHENING SHOULDER *A*, FIG. A

The scale was built to be of sufficient length and capacity to weigh the largest locomotive or car built at the present time or likely to be built for many years to come.

With a concentrated load of 275,000 lb. per section and 137,500 lb. per main lever, the problem presented itself of producing a knife edge in the main levers of sufficient length to reduce the load per lineal inch below 7000 lb. (American Railway Association specification) and to properly support it so as to insure an equal distribution of the load throughout its length without undue deflection. To do this a double web construction was adopted, as with this construction connected by heavy transverse sections over and under the knife edges, a very efficient support is obtained throughout the full length of the knife edge. The load and fulcrum knife edges in the main lever are 21 in. long.

To preserve the true relative position of the main lever stands with the end and the middle extension lever stands and to insure stability, a system of transverse bracing is used. This bracing consists of heavy T-section members securely attached by flange connection to the lever stands.

The material used for pivots and bearing steels throughout the scale was high grade chromium-vanadium alloy steel with a tensile strength of 200,000 lb. per sq. in., hardened in oil. With this grade of steel very little trouble was experienced in keeping the long knife edges straight, and consequently very little grinding was necessary after the pivots and bearings were hardened.

After installation at West Albany the scale was tested with two test cars weighing respectively 80,000 and 60,500 lb. Each section was tested separately with each of the cars, and a variation of less than 10 lb. was established by the results. The same degree of accuracy was attained when both cars were used giving a test load of 140,500 lb., and the sensibility reciprocal was 20 lb. (*Scale Journal*, vol. 2, No 11, p. 5, August 10, 1916, 3 pp., 11 figs. *d.*)

Munitions

EFFECT OF GRAVITATION ON THE FLIGHT OF PROJECTILES

A general, rather elementary discussion of the conditions governing the flight of projectiles, with an elementary formula concerning vertical, horizontal and angular projection. (*Canadian Machinery and Manufacturing News*, vol. 16, no. 11, p. 279, September 14, 1916, 3 pp., 4 figs. *g.*)

RECLAIMING RUSSIAN THREE-INCH SHRAPNEL FUSE BODIES, H. M.

Many manufacturers in the earlier stages of the development of the munitions industry did not realize the high degree of accuracy insisted upon by the inspection for the Russian fuse, and have undertaken to produce them by the usual various makeshift tools. The result was that much of the work was rejected and many producers are now, when they have learned more about the industry, turning their attention to the reclaiming of some of the rejected work.

Of course, much of this work either cannot be saved at all, or the parts are so simple that it is not worth the trouble. However, the case is different with some other parts.

One of the most expensive parts of the fuse is the body shown in Fig. 3A, which in the case of the 3-in. fuse is made from an aluminum composition casting which is compressed and machined all over. A large number of these bodies have been rejected owing to the shoulder *A* being too short. If the diameter *B* has sufficient stock to permit, this diameter can be rolled with a tool such as is shown in Fig. B, which compresses the metal lengthwise, thereby lengthening the shoulder *A*. The tool Fig. B consists merely of a roll *A* mounted on a stud *B* in a suitable holder *C* which is sufficiently strong to resist the pressure of rolling the aluminum over. The work is held on the large diameter in chuck jaws *D* and is supported by the back rest *E*.

Another trouble was that the pitch diameter *C*, Fig. A, was very slightly too small. As the tolerance on the outside diameter of the thread is greater than that allowed on the pitch diameter, it is often possible to reclaim bodies rejected from this cause by rolling the thread with the tool Fig. C. This tool

was made with the idea of jamming the top of the thread and thereby causing the metal to be squeezed outward at the pitch diameter.

This tool is smaller in construction than that shown in Fig. B, with the exception that it was made straight instead of offset.

To save bodies which had the diameter *E* bored out too much it was found that there were two chances to save them: First, if the diameter *D* had sufficient stock to permit of rolling with the tool Fig. D the top diameter was squeezed, thereby causing the metal to be compressed sufficiently to allow of boring the diameter *E* to the correct size. With this method it was usually found necessary to trim up the face *X* at the bevel side. The other method of reclaiming the bodies is to apply a roll on the surface *F* provided the depth *G* is long enough to permit

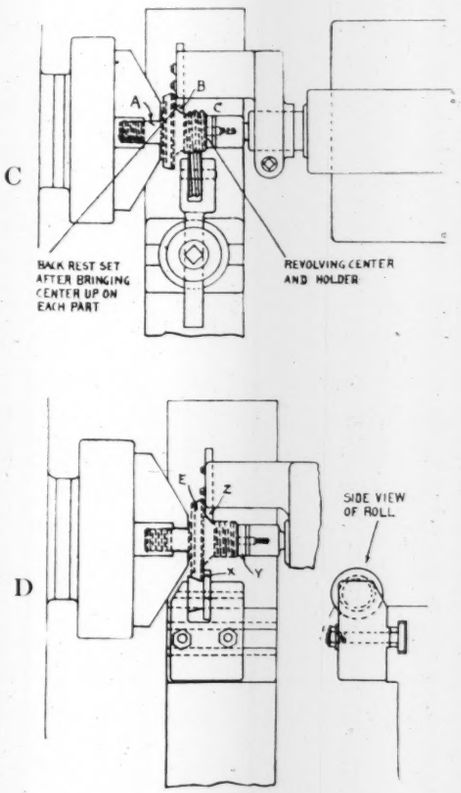

FIG. 3 METHODS OF RECLAIMING RUSSIAN 3-IN. SHRAPNEL FUSE BODIES: C, METHOD OF ROLLING THREAD TO INCREASE PITCH DIAMETER; D, ARRANGEMENT OF TOOLS USED FOR ROLLING OUTSIDE DIAMETER

this. A special roll for accomplishing this is shown in the original article. (*Canadian Machinery and Manufacturing News*, vol. 16, no. 11, p. 287, September 14, 1916, 1 p., 5 figs. *d.*)

Pile Drivers

PILE DRIVING

Description of a pile extractor built by the Ransome-ver-Mehr Machinery Company, Ltd., London, England.

The usual methods for drawing of piles are still somewhat primitive. In cases where the tops of the piles are under water level, as in bridge foundations, the usual procedure has been to attach the piles to the top of a barge or pontoon so that the rise of the tide and the buoyancy of the pontoon drew the piles from the bottom of the river or the sea bed. This is a slow and dangerous process and besides not applicable where there is no tide. In land operation equally crude methods are used, such as drawing the piles by jacks, union screws or pulley blocks suspended to a crane.

The extractor described here is devised to reverse the process of pile driving. Instead of the blow being struck by the force of gravity acting on a hammer dropped from a height onto the top of the pile, steam is utilized in the cylinder to give an upward blow to an anvil in the form of a crosshead which is connected by vertical links to a grip-box placed under the cylinder and carrying wedge-shaped serrated jaws which, with the grip-box, surround the pile, so that as the steam impinges on the piston and strikes the anvil, an upward pull is exerted on the top of the pile through the connecting links and the grip-box. Fig 4 shows in detail the main units of the extractor. *A* is the piston or monkey working in the cast-steel cylinder *B; D, D* are the forged-steel connecting rods to the cast-steel grip-box *E,* in which are fitted the serrated cast-steel jaws *F* to engage with the pile *G.*

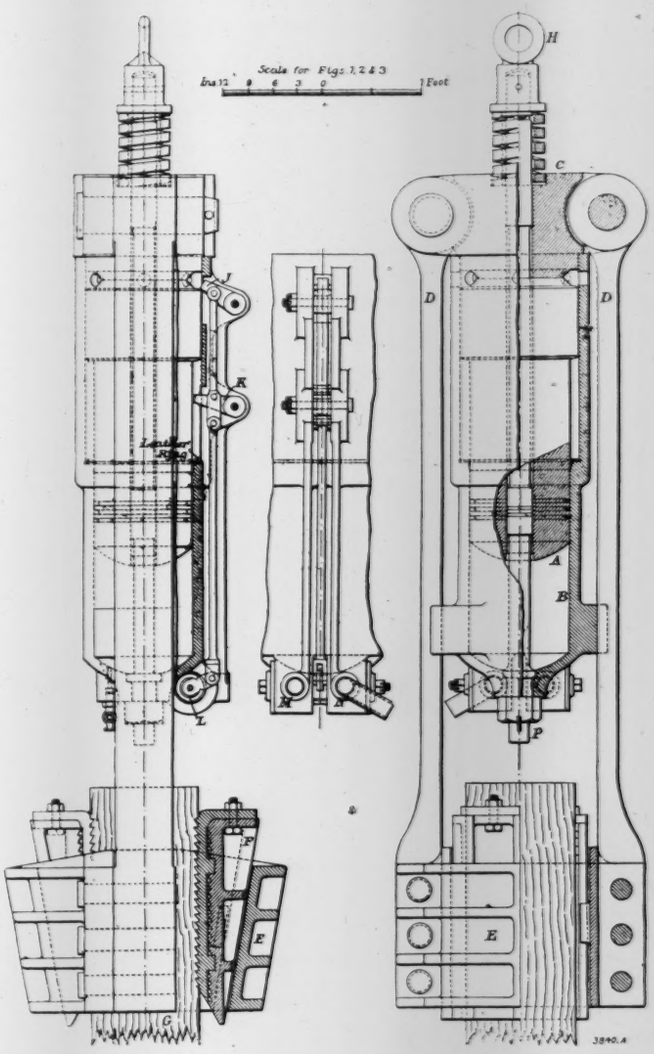

FIG. 4 RANSOME PILE EXTRACTOR

Of course the cylinder cannot operate under the water level, but this can be overcome by increasing the length of the con-

necting rods between the anvil and the grip-box. An important element in the success of the extractor is the abundance of steam supply. This is transmitted through flexible tubing. Once the hammer action has commenced it is important that it should not cease until the pile has been extracted or is sufficiently loose to enable it to be easily withdrawn by a small crane or by winches arranged to do so. If there is any discontinuity in the hammering, the jaws are likely to get out of position.

The method of suspending the extractor is another important element in its success and rapidity of operation. In some cases it is hung on a pile-driving machine, but in one of the most effective installations a 10-ton steam derrick crane is utilized having a 60-ft. jib. The kingpost under the mast is mounted on a 3-wheeled bogie. One of the two guys is mounted on a 2-wheeled bogie and the other on a 3-wheeled bogie, which also carries the boiler to supply steam to the extractor. This crane installation has the advantage that the extractor is free to oscillate when in operation, which helps in slackening the pile. Moreover, when the extractor is working,

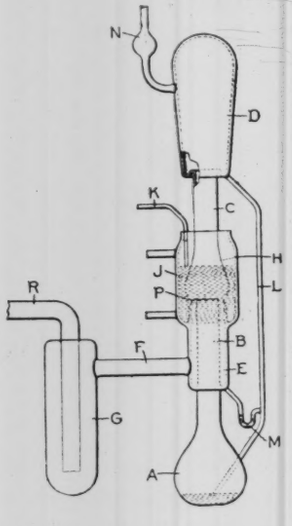

FIG. 5 HIGH-VACUUM MERCURY SPEED VAPOR PUMP OF EXTREME SPEED

the crane engine is set in motion, maintaining a tensile strain on the suspension wire rope so that the hammer action of the extractor is assisted by the pull on the crane. Further, the crane does not have to be moved for every pile, as in the case described it commands an arc of 270 deg.

In one of the shipbuilding berths there were about 1200 piles 13 to 14 in. square, ranging in length from 29 to 36 ft. in the upper part of the berth and from 15 to 20 ft. at the lower part. All were driven for their full length into the London clay. The average time for drawing a pile was well under 3 min., although in a few cases as long as 10 min. have been taken. The plant as equipped and in operation cost about £1500 (roughly $7500). (*Engineering*, vol. 102, no. 2644, p. 198, September 1, 1916, 3 pp., 7 figs. *d.*)

Pumps

A HIGH-VACUUM MERCURY-VAPOR PUMP OF EXTREME SPEED, Irving Langmuir

The new pump is based on the same principle as aspirators or ejectors, in which a blast of steam or air is used to produce a partial vacuum. In these devices the high velocity of the jet of steam causes a lowering of pressure, so that the air to be exhausted is sucked directly into the jet. If, however, the jet were surrounded by a perfect vacuum, there would be a blast of gas molecules escaping from the jet into this vacuum, and therefore it is not possible to obtain a very high vacuum by means of an instrument based on the principle of the ordinary ejector or aspirator.

The action of these instruments consists really of two processes: (1) the process by which the air is drawn into the jet; (2) the action of the jet in carrying the admixed air into the condensing chamber.

The aspirators cease operating at low pressures because of the failure of these processes. If air at low pressure could be made to enter the jet, and if gas escaping from the jet could be prevented from passing back into the vessel to be exhausted, then it should be possible to construct a jet pump which would operate even at the lowest pressures.

Gaede has recently described a pump, called a diffusion pump, in which a blast of mercury vapor carries along the gas to be exhausted into the condenser. In order to introduce the gas into the blast of mercury vapor, Gaede has used diffusion through a slit of a width comparable with the mean free path of the mercury atoms in the blast. A portion of the mercury blast escapes through the slit, and the gas to be exhausted diffuses in against this blast of mercury vapor. This renders it necessary to make the slit very narrow (about 0.1 mm), and for this reason the speed of the pump is necessarily low (only about 80 cc. per second as against 1300 cc. per second for the molecular pump.

The writer found that there are other methods by which the gas to be exhausted may be introduced in the blast of mercury vapor, and out of this has been developed the type of pump shown in Fig 5, which has given satisfactory results.

In this device a blast of mercury vapor passes upward from the heated flask *A* through the tubes *B* and *C* into the condenser *D*. Surrounding *B* is an annular space *E* connecting through *F* and the trap *G* with the vessel to be exhausted. The tube *C* is enlarged into a bulb *H* just above the upper end of the tube *B*. This enlargement is surrounded by a water condenser *J*, from which the water is removed at any desired height by means of the tube *K*, which is connected to a water aspirator. The mercury condensing in *D* and *H* returns to the flask *A* by means of the tubes *L* and *M*. The tube *N* connects to the "rough" or "backing" pump, which should maintain a pressure considerably lower than the vapor pressure of the mercury in *A*.

In this pump, the mercury atoms escaping from the upper end of the tube *B* radiate out in all directions. A part of them passes up into *C*, but the larger part strikes the walls of the enlargement *H*.

If there is no water in the condenser *J*, the mercury which condenses on the walls reëvaporates nearly as fast as it condenses. The molecules passing from the end of the tube *B* towards the walls *H* collide with the molecules with reëvaporate, and may then be deflected downward into the annular space *E*. This blast of mercury vapor down through *E* prevents the gas from *F* from passing up into *H*, so that under these conditions the gas from *F* may pass through the pump much more slowly than if no mercury vapor were produced in *A*.

On the other hand, when cold water circulates through the condenser *J*, all the mercury atoms striking the walls of *H* are condensed, so that no mercury passes down through *E*. The gas from *F* thus passes freely up through *E*, and when it

meets the mercury-vapor blast at P is blown outward and upward along the walls of the condenser H, and finally forced into the main stream of mercury vapor passing up through C into the condenser D.

A vessel of eleven liters capacity was connected to R. Air was admitted to the vessel and the pressure was found to decrease as follows:

Time Sec.	Pressure in Bars at R	Pressure in Bars at D	Time Interval, Sec.	Speed in Cc. per Sec.
0	1.470	1.160		
30	294	720	30	590
60	12.8	218	30	1,150
80	0.015	18	20	3,700

The rough pump used had a speed of about 200 cc. per second at pressures of 400 bars, but this speed fell off to 60 cc. at 40 bars, and became zero at about 10 bars. The speed of the mercury-vapor pump increased rapidly as the pressure decreased and reached a limit of about 4000 cc. per second at pressures below 10 bars. Theoretical considerations would indicate that this speed should remain constant down to the very lowest pressures.

Several experiments with hydrogen showed that the maximum speed with this gas was about 7,000 cc. per second. (*Physical Review*,) vol. 8, no. 1, p. 48, July, 1916, 4 pp., 1 fig. *d*.)

Centrifugal-Pump Casings

Centrifugal pumps of the turbine type have been usually built with solid cylindrical casings or casings split in the horizontal center plane. Sometimes pumps have been made with casings divided at right angles to the axes—the number of units generally corresponding with the number of stages—and held together by bolts or studs passing from end to end. The design with one cylindrical casing for all stages has the drawbacks that special patterns are necessary for any required number of stages, and that dismantling may be troublesome owing to internal parts sticking to the casing due to rust. The drawback of the pump built in stages without an outer casing is the impossibility of dismantling the pump without breaking either the suction or delivery-pipe joint.

In order to obviate the drawbacks of both constructions, Rufener & Wiesengrund, of Horton Bridge, Yiewsley, Middlesex, England, have patented assembled-stage casings which have water-tight joints between each other in a plain outer cylindrical casing; this latter can be molded with a striking board, and is not subject to any water pressure, but merely serves to hold together the separate suction and delivery ends of the pumps, besides centering the stage casings.

The delivery end is made with such internal diameter that all the stage casings can be withdrawn without fouling the delivery end. It is an annular chamber with a circular cover which contains the automatic balancing device, varies the delivery-end bearing, and, when bolted to the annular delivery chamber, holds the various stage casings firmly together. In order to take the pump to pieces it is only necessary to take off the delivery-end cover, when all internal parts of the pump can be withdrawn without breaking any pipe connection.

Referring to the Fig. 6, A is the suction end of the pump bolted to the cylindrical outer casing B. C, J, etc., are the stage casings contained in outer casing B. The first-stage casing is fitted to the suction end A with water-tight joints, and similar joints are formed between the stage casings, the number of the latter varying according to requirements. The last-stage casing marked K is provided with a flange and projections E. A small clearance space is allowed between the flange of the last-stage casing and the flange of the outer casing. Into this clearance space a packing ring F, of suitable material, is inserted. Centered on the flange L of the outer casing and bolted to the latter is the annular delivery chamber D. Bolted to the delivery chamber is the end cover G. A clearance space is provided between the flange of the end cover and the delivery chamber, the water-tight joint being made by a suitable packing ring H. When the end cover G is bolted to the delivery chamber, its inside press against the projections E, and thus establishes the tight fit of the water-tight joints of the stage casings. It will be seen that with this construction the stage casings, with the parts which they contain, can be withdrawn after removal of the end cover G, while suction end A and delivery chamber D remain in position bolted to outer casing B, so that the pipes which join on to A and D, respectively, can remain undisturbed. (*Mechanical Engineer*, vol. 38, no. 968, p. 98, Aug. 11, 1916, 1 p., 1 fig. *d*.)

Refrigeration

Raw-Water Can Ice, Van R. H. Greene

Raw-water can ice was first put in use in St. Louis many years ago, but the process has lain dormant until the last two years because of the difficulties that were experienced in this St. Louis plant in making ice that was marketable. The system most frequently installed at first by the ice-machine builders was that of low pressure, which means that air was forced through a tube suspended vertically in an ice can filled with water with just sufficient pressure to agitate the water in the can. The result of this agitation was the washing of the air bubbles away from the sides of the forming ice and the rendering of the ice clear and transparent so long as the tube continued to blow air into the water in the can. When, however, the tube suspended in the water was reached by the formation of the ice, the outlet of the tube was closed and air ceased to blow from that point, making a core in the ice block which was opaque and white, due to the presence of air. This core could be eliminated by the removal of the tube just prior to the time that it would be frozen into the ice, sucking out the unfrozen core water and replacing it by distilled or by raw water which had previously been cooled.

The use of distilled water was objectionable because it gave the same unpleasant odor and core test as was characteristic of a distilled-water block, the avoidance of which is the whole aim of the raw-water can ice system. A better plan was to replace the core water by precooled fresh raw water.

Then Mr. Beals of Detroit discovered that it required some two pounds pressure to blow air through ice which had been formed around the outlet of the air tube, and that the presence of the ice surrounding the tube soon deposited out the moisture which is in all air and caused it to freeze inside of the tube, ultimately plugging it up entirely.

He therefore designed a double-pipe air dryer by which the air was thoroughly dried before being admitted into the ice-can tube, and the pressure was raised sufficiently high to cause the air to blow through the ice, even after the ice had frozen solid around the tube outlet (high pressure system).

In the high pressure system a pressure of approximately 45 lb. is used, the air being allowed to expand in the air tube from this pressure down to a pressure of approximately two pounds. The blowing of air against a pressure of 45 lb. requires, of course, much more horsepower than does the blowing of a smaller quantity of air against a pressure of four pounds. This increase of horsepower is, however, somewhat

compensated by the volume of air blown into the cans being smaller than with the low pressure system; nevertheless, the horsepower required in the high pressure system is approximately twice that used in the low pressure system.

Another system, in the development of which the writer was associated, has the ice tube suspended from the sides of the cans into the water and not made an integral part of the ice cans, as in the case of the Beals and York systems. The result is that it is only necessary to compress the air to a pressure sufficiently high that when cooled to 36 deg. fahr. and expanded to 2 lb. pressure or so the dew point of the air will be slightly below that of the temperature of the surrounding ice rather than the surrounding brine.

Tests which the writer made at the plant of the Independent Ice Company, of Baltimore, Md., show that the temperature of the ice surrounding the tube seldom gets below 20 deg. fahr., which makes it possible to keep this air blowing by compressing it to 25 lb. pressure per sq. in. instead of 45 lb., and producing the same results as do the other systems. With this system the air tube is frozen into the ice block and must be removed by some means before the cake can be placed on sale. At the plant in Baltimore this is accomplished by injecting a steam jet into the ice block. Where the plant must be operated by electric power or by an oil or gas engine, difficulty will be experienced in thawing out this tube economically. The writer has tried out a scheme of winding the air tube with resistance wires and thawing it out electrically. In his opinion, the only objection that can be found to such a method lies in the fact that with the additional winding the air tube becomes of a diameter slightly larger than ½ in., and leaves a hole remaining in the ice block which might be objectionable in appearance to certain classes of trade.

In the writer's opinion, the secret of manufacturing raw-water can ice lies in two points—the ability to agitate the water continuously until the block is frozen solid, and the making use of water for ice-making purposes which is suitable for this requirement. (*Refrigerating World*, vol. 51, no. 2, p. 27, August, 1916, 3 pp., 3 figs. *de.*)

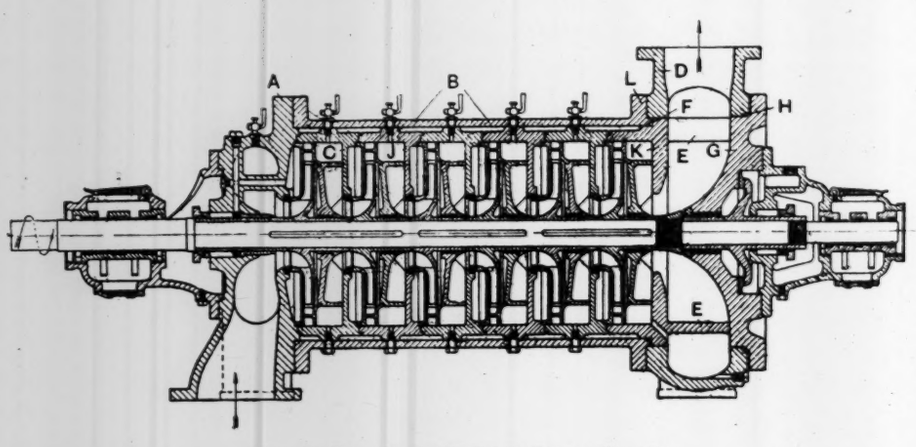

FIG. 6 IMPROVED TURBINE PUMP CASING

Steam Engineering

THE AIR SUPPLY TO BOILER-ROOMS ON WARSHIPS

In a pamphlet recently published, Mr. R. W. Allen, M. Inst. C. E., of the Queen's Engineering Works, Bedford, has collected together some valuable data on the supply of air to boiler rooms. He lays special emphasis on the need of providing ample and unobstructed airways in order to avoid a waste of the head generated. The head wasted varies nearly as the square of the air velocity, as it is not practicable to reconvert into pressure head any substantial fraction of the velocity head of the moving fluid. Mr. Allen quotes a number of cases of excessive velocities in the air shafts of different warships, ranging from 48 ft. up to 78 ft. per sec. In practice a high velocity in the air ways means that the effective gage in the boiler room is reduced by the head equivalent to this velocity. With such an air speed as 78 ft. per sec. this reduction amounts to 2 in. That these excessive speeds are not unavoidable is shown by the quotation of other figures, where even on destroyers the air velocity has been kept down to 42 ft. per sec. In certain cases the air shafts have been thought convenient places for the storage of hose, etc. In other cases pipes have been led through them, with little or no consideration, to the consequent obstruction of the air way. Again, the openings above deck are often far from as free as is desirable. Deck erections, for example, may obstruct the access of air to the whole of one side of the intake, and some instructive examples of this are given. The armor bars or gratings are also commonly of bad form. Experiments made at Bedford with bars of "fair form" instead of rectangular showed with the fair form a zero pressure drop across the grating, while with the rectangular bars the loss of head due to the obstruction was 0.22 in. (water gage) with a velocity of 53.7 ft. per sec. Mr. Allen states that when two fans are mounted close together their performance can be greatly improved by fixing appropriate deflector plates so that the air currents as delivered shall not interfere with each other, and similar plates have also proved advantageous even with single fans, tests made with ribbons in the boiler rooms having shown that in many cases the air is far from taking the most direct line to the furnaces. In conclusion, Mr. Allen draws attention to the great progress which has been made of recent years in fan design, which he illustrates very strikingly by comparative photographs of the impellers of the old and of the new type. The same duty is now obtained from an impeller 52 in. in diameter as from one of 81 in. in diameter a few years ago. (*Engineering*, vol. 102, no. 2643, p. 174, August 25, 1916, 1 p. *p.*)

HEAT-TRANSMITTING TUBES FOR EVAPORATORS

A patent has recently been granted to Watson and Billetop, of Newcastle-on-Tyne, England, in which heat-transmitting

tubes for evaporators are provided with a carrier plate adapted to form a longitudinal medial division plate in the tube, dividing the flow of fluid into two streams, and to carry a series of baffle plates alternately arranged so that successive plates are opposite one another, whereby each of the two streams is sigzagged and effectively baffled by the one set of plates as shown in Fig. 7-1. The tube A is fitted with a carrier plate B of width equal to the diameter of the tube. This plate is notched at F, Fig. 7-7. The baffles C and G are shaped as shown Figs 7-5-6, which show them reversely set; they are all of the same shape, but alternate sets are oppositely disposed as shown

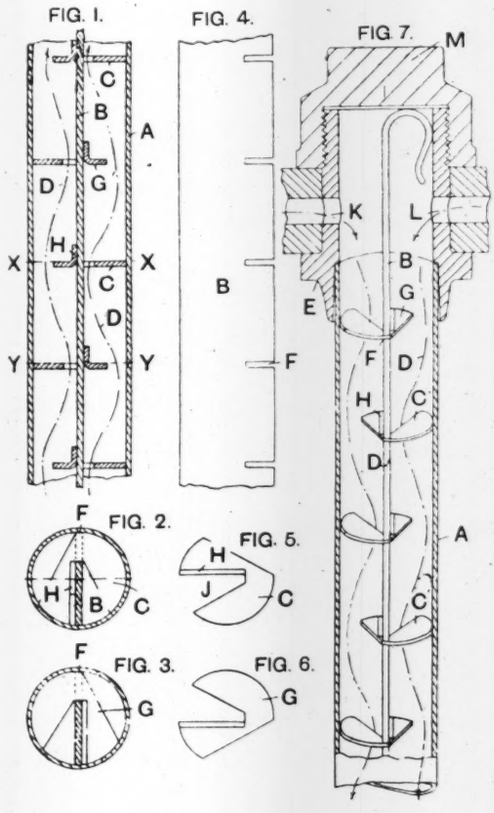

FIG. 7 IMPROVED EVAPORATOR TUBE

in Figs 7-1-7. They are held in position by being fitted into the notches F of the plate B and are attached thereto by means of the lugs H which are turned up when forming the V-notches J in the baffles. The plate B divides the fluid passing through the tube into two streams, and the alternate arrangement of the baffles causes each stream to take a zigzag path, as shown by the dotted chain line D. Fig. 7-7 shows the tube connection E fitted with ports K and L and with the coupling nut M. Upon removal of this nut the plate B can be withdrawn with the baffles in position by means of the handle shown. (*The Mechanical Engineer*, vol. 38, no. 971, p. 171, September 1, 1916, 1 p., 7 figs. *d.*)

DESIGN OF SUPERHEATERS, William C. Strott

The writer gives a formula for calculating the amount of surface required for a superheater under varying conditions of service.

The formula is as follows:

$$x = \frac{10S}{2(T-t)-S}$$

where x = sq. ft. of superheating surface required per boiler horsepower
S = superheat required in deg. fahr.
T = temperature of furnace gas at superheater in deg. fahr.
t = temperature of saturated steam at boiler pressure in deg. fahr.

The value of T can be obtained from the following equation:

$$\frac{1}{(T-t)^{0.16}} = (0.172H + 0.294)$$

where H is the percentage of boiler-heating surface between the furnace and superheater.

The author gives an example for using this formula. It is to be remembered that it is assumed that steam is a perfect gas; for every one per cent of moisture in the saturated steam, allow fifteen per cent more superheater surface than found by the use of this formula. (*Power*, vol. 44, no. 6, p. 199, August 8, 1916, 2 pp. *p.*)

Testing

APPARATUS FOR TESTING CRESCENT SCREWDRIVERS, C. L. L.

Description of an apparatus for testing the strength of screwdrivers and detecting soft blades or other hardening defects.

The apparatus is very simple. Upon the side of the testing wall a center stud is located on which a long lever is pivoted. The fulcrum point of this lever is slotted to receive the screwdriver blade. The lever is approximately 24 in. long and is attached at its outer end to the weight hook of a spring balance after the weighing pan has been removed.

The inspector inserts the blade of the screwdriver in the slot at the center of the pivot arm and with a wrench turns the arm and pulls down the scale beam until the indicator reaches a predetermined number of pounds. If the blade fails to bend or break the screwdriver is adjudged perfect, otherwise it is rejected. (*Machinery*, vol. 22, no. 12, p. 1025, August 1916, 1 p., 1 fig. *d.*)

CLASSIFICATION OF ARTICLES

Articles appearing in the Survey are classified as *c* comparative; *d* descriptive; *e* experimental; *g* general; *h* historical; *m* mathematical; *p* practical; *s* statistical; *t* theoretical. Articles of especial merit are rated *A* by the reviewer. Opinions expressed are those of the reviewer, not of the Society. The Editor will be pleased to receive inquiries for further information in connection with articles reported in the Survey.

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CHARACTERISTIC CURVES FOR WING SECTION, R. A. F. 6, H. W. Rossell. Aerial Age Weekly, vol. 3, no. 23, August 21, 1916, 1 p., illustrated.

FIRST AEROPLANE WITHOUT WIRES. Aerial Age Weekly, vol. 3, no. 23, August 21, 1916, 1 p., illustrated.

L'ETAT ACTUEL DE L'AÉRODYNAMIQUE. L'Aérophile, 24 Annee, nos. 13-14, 1-15 Juillet 1916, 8 pp., illustrated.
Present state of aerodynamics (serial).

LES HYDRAVIONS ALLEMANDS, L'HYDRAVION BIMOTEUR. L'Aérophile, 24 Annee, nos. 13-14, 1-15 Juillet 1916, 6 pp., illustrated.
German hydroaeroplanes.

THE BERKSHIRE MAGNETO. Aerial Age, vol. 3, no. 24, August 28, 1916, 1 p., illustrated.

EXPERIMENTS ON A DIHEDRAL ANGLE WING, J. C. Hunsaker and D. W. Douglas. Aerial Age, vol. 3, no. 24, August 28, 1916, 1 p., 2 figs.

AIR MACHINERY

DRY COMPRESSED AIR FOR POWER MACHINERY. Steel and Iron, vol. 50, no. 8, August 1916, 1½ pp.

ACTUAL COSTS OF MINE HAULAGE BY HORSES AND BY COMPRESSED AIR, Ravul Green. Compressed Air Magazine, vol. 21, no. 9, September 1916, 1¼ pp.

A HANDY PNEUMATIC PRESS FOR RAILROAD YARDS. Compressed Air Magazine, vol. 21, no. 9, September 1916, 1¼ pp., 4 figs.

CONVEYING

THE MATHEWS GRAVITY CARRIERS. Engineering, vol. 102, no. 2645, September 8, 1916, 1 p., 5 figs.

ENGINEERING MATERIALS

INVAR AND RELATED NICKEL STEELS. Circular of the Bureau of Standards, no. 58, April 4, 1916, 68 pp., illustrated.

THE ANNEALING PROPERTIES OF COPPER AT TEMPERATURES BELOW 500 DEG. C., WITH PARTICULAR REFERENCE TO THE EFFECT OF OXYGEN AND OF SILVER, G. V. Caesar and G. C. Gerner. A paper presented at the Annual Meeting of the American Institute of Metals, September 11-15, 1916, at Cleveland, Ohio, no. 6, 41 pp., 10 figs.

ALUMINUM CASTINGS AND FORGINGS, P. E. McKinney. A paper presented at the Annual Meeting of the American Institute of Metals, September 11-15, 1916, at Cleveland, Ohio, no. 15, 6 pp.

COPPER-CLAD STEEL WIRE. Electric Railway Journal, vol. 48, no. 10, September 2, 1916, ½ p.

"THE THOMAS TRANSMISSION" RAIL MOTOR CAR. Railway Engineering, vol. 29, no. 9, September 1916, 1 p., illustrated.

PROPORTIONAL CONSTITUENTS OF NON-FERROUS METALS, G. F. Zimmer. The Metal Industry, vol. 9, no. 7, August 18, 1916, 2 pp.

THE USE OF CHEAPER MATERIALS, Charles C. Kawin. Preprint published by American Foundrymen's Association, 5 pp.

THE THERMAL REACTIONS OF CAST IRON, Thomas Turner. Preprint published by American Foundrymen's Association, 10 pp., 2 figs.

COLD-ROLLING STRIP STEEL, Edward K. Hammond. Machinery, vol. 23, no. 1, September 1916, 6 pp., illustrated.

NORMAL FRACTURE OF GOOD MALLEABLE IRON, Enrique Touceda. The Iron Age, vol. 1, no. 5, September 14, 1916, 2 pp., illustrated.

FOUNDRY

THE EFFECTS OF DIFFERENT MIXTURES ON THE STRENGTH OF CHILLED CAR WHEELS, G. S. Evans. American Foundrymen's Association (Cleveland meeting, September 1916), 43 pp., illustrated.

REPORT OF COMMITTEE ON SPECIFICATIONS FOR STEEL CASTINGS. American Foundrymen's Association (Cleveland meeting, September 1916), 4 pp.

ANALYZING FOUNDRY OPERATIONS AS A BASIS FOR IMPROVEMENT IN SHOP CONDITIONS, R. E. Kennedy. American Foundrymen's Association (Cleveland meeting, September 1916), 19 pp., illustrated.

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